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THE QUARTERLY BULLETIN

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THE QUARTERLY BULLETIN

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MICHIGAN STATE COLLEGE
AGRICULTURAL EXPERIMENT STATION
EAST LANSING

L. M. TURK, DIRECTOR
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IMPORTANT FACTORS INFLUENCING THE GROWTH OF A CO_2-DEPENDENT STRAIN OF *BRUCELLA ABORTUS* IN A LIQUID CULTURE MEDIUM IN THE PRESENCE OF BLOOD

By I. FOREST HUDDLESON

DEPARTMENT OF BACTERIOLOGY AND PUBLIC HEALTH

STUDIES of the writer have revealed that small numbers of cells of certain CO_2-dependent strains of *Brucella abortus* do not multiply rapidly in the liquid culture mediums now in use. Inhibition of growth of the cells is even more pronounced when whole blood is added to the culture mediums. This could be attributed to the nature of the culture medium or to biochemical changes that occur during incubation.

Stewart *et al.* (1935) considered the growth-inhibiting action of the bactericidal antibody-complement system to be an important factor in preventing the isolation of *Brucella* from blood of infected humans. They found that this system could be inactivated by heating the blood at 56° C. for 15 minutes. Haring and Traum (1937) encountered the same problem in attempting to isolate *Br. abortus* from the blood of infected cows. Their attempts also met with success when the blood was heated at 56° C. for 15 minutes.

The results of the study reported herein show that at least five factors must be considered in order to obtain rapid growth of less than 50 CO_2-dependent brucella cells in the presence of blood. These are 1) the medium constituents, 2) the H-ion concentration of the medium, 3) the concentration of CO_2 in closed containers during the period of incubation, 4) the bactericidal action of blood, and 5) the glycolytic action of erythrocytes in blood.

The data presented herein summarize the experiments that were performed to determine the conditions that promote the rapid growth of a CO_2-dependent strain of *Br. abortus* in liquid mediums without blood and in its presence.

ARTICLE 37-1

MEDIUMS AND PROCEDURE WITHOUT BLOOD

The liquid mediums used in the initial studies were tryptose, peptone M, trypticase soy, beef liver infusion, and potato infusion. They were prepared either from pre-mixed bases of the manufacturer or from the constituents recommended. The mediums were distributed in 20 ml. amounts into 50 ml. serum bottles. The bottles were plugged with absorbent cotton and autoclaved according to the recommended procedures.

The bottles of medium were inoculated with less than 50 living cells (plate colony count) of a fastidious, CO_2-dependent strain of *Br. abortus* and immediately placed in glass jars. After the jars were closed tightly, 5 or 10 percent of the air was replaced with CO_2.

All mediums prepared according to the recommended formulas failed to initiate growth that was visible to the eye during a 3-day incubation period at 37° C. This length of time was considered sufficient for evaluating the growth-promoting property of each of the mediums. The negative results led to a study of the effect of adjusting the pH with different agents and the CO_2 concentration in closed jars on the growth of brucella cells.

The agents used for adjusting the H-ion concentration of the culture mediums were $NaHCO_3$, Na_2CO_3, NaOH, and K_2HPO_4. Sodium bicarbonate was used not only as a means of controlling the pH but, in addition, as a source of CO_2 when the medium containers were sealed.

It is known that $NaHCO_3$ in solution in an open container is unstable and dissociates slowly into CO_2 and Na_2CO_3. This also occurs in a solution in a closed container until equilibrium is established between $NaHCO_3$ and its products of decomposition. At equilibrium there will be present in solution $NaHCO_3$, Na_2CO_3, CO_2, and H_2CO_3, as well as the ions formed from the dissociable compounds. When $NaHCO_3$ is added to liquid culture medium, the change in the pH will depend on the amount of $NaHCO_3$ added and whether the container is kept open or closed. If unsealed containers (bottles) of a medium containing $NaHCO_3$ are placed in jars to which CO_2 is added, the ultimate pH of the medium will be determined by the volume percentage of CO_2 in the jars and the amount of $NaHCO_3$ added to the medium.

The method used for controlling the pH and quantity of CO_2 with $NaHCO_3$ follows: A 0.9 *M* solution of $NaHCO_3$ (C.P.) was prepared in distilled water (25° C.) and sterilized by filtering through a D8 Hormann pad in a Seitz filter. A fresh solution was prepared within

one hour of its addition to the mediums (20° C.). The amounts of the solution to be added to the bottles of sterile medium (pH 6.8 - 6.9) to obtain different initial pH levels were determined on a sample of the medium by means of a glass electrode pH meter. Shortly after adding the inoculum (suspension of cells diluted to contain from 10-35 cells/0.3 ml.), the required amount of bicarbonate solution was measured into each bottle, and the bottles were either sealed (rubber stopper) within 2 minutes or placed in jars for addition of CO_2, depending on the nature of the experiment. All containers were incubated at 37° C. and examined daily for 3 days for the appearance of visible turbidity. At the end of the third day, the pH of each bottle of medium was determined (20° C.) as previously mentioned, and the degree of turbidity, if any, measured in a photronreflectometer. Scale readings were converted into approximate total cells/ml.

RESULTS

Data representing a few of the many experiments performed with one culture medium, namely, trypticase soy, and with varying amounts of three different agents for adjusting the pH are recorded in Table 1. The data show that the changes in the pH of the medium incubated in sealed bottles and in unsealed bottles in CO_2 depend on the amount of Na_2CO_3 or $NaHCO_3$ added.

The degree of growth obtained at the end of 72 hours was approximately the same when the medium was adjusted to pH 7.1 with $NaHCO_3$ and incubated in atmospheres containing 5 and 10 percent CO_2. Similar results were obtained in the medium adjusted to pH 7.4. The pH level at the end of the incubation period, however, was 0.5 to 0.7 higher.

The most rapid multiplication of brucella cells occurred in the medium that was adjusted to pH 7.1 with $NaHCO_3$ and incubated in sealed bottles. The degree of growth obtained by this procedure was greater than that obtained in a medium raised to pH 8 with Na_2CO_3 and incubated in jars containing 5 or 10 percent CO_2 by volume even though the pH was optimum for growth within the first 24 hours of incubation.

When the culture medium was adjusted with Na_2CO_3 and incubated in either 5 or 10 percent CO_2, an initial pH of 8 was found to be optimum for rapid multiplication of brucella cells. Visible growth was not present in medium adjusted to an initial pH of 7.3 with K_2HPO_4 and incubated for 72 hours in either 5 or 10 percent CO_2.

TABLE 1—Effect of pH adjustment and concentration of CO_2 on growth of a CO_2-dependent strain of Br. abortus in liquid medium (*)

Bottle No.	pH adjustment and agents used†	Inoc. cells added‡	Atmosphere percent CO_2§	Incubation 72 hours at 37°C.	
				Visible turbidity ¶	pH
1	6.9 No adjustment	20	Normal**	—	6.8
2	6.9 No adjustment	20	5	—	6.5
3	7.1 $NaHCO_3$	20	Normal	—	8.4
4	7.1 $NaHCO_3$	20	5	3+	7.1
5	7.1 $NaHCO_3$	12	10	3+	7.0
6	7.4 $NaHCO_3$	20	Normal	—	9.0
7	7.4 $NaHCO_3$	20	5	3+	7.7
8	7.4 $NaHCO_3$	12	10	3+	7.5
9	7.1 $NaHCO_3$	20	Sealed††	5+	7.3
10	7.4 $NaHCO_3$	20	Sealed††	4+	7.7
11	7.1 Na_2CO_3	20	Sealed††	—	7.2
12	7.1 Na_2CO_3	20	5	—	6.8
13	7.1 Na_2CO_3	20	10	—	6.6
14	7.4 Na_2CO_3	20	5	4+	7.2
15	7.4 Na_2CO_3	20	10	1+	6.8
16	8.0 Na_2CO_3	30	5	4+	7.3
17	8.0 Na_2CO_3	30	10	3+	7.1
18	7.3 K_2HPO_4‡‡	30	5	—	6.9
19	7.3 K_2HPO_4‡‡	26	10	—	6.7

*Trypticase soy formula minus dibasic phosphate.
†Agent added at time of inoculation unless indicated.
‡Plate colony count.
§Added to closed glass jars.
**Bottle closed with cotton plug.
††Bottle closed with rubber stopper after adjusting pH.
‡‡Added before autoclaving.
¶ — = No turbidity.
1+ = 1 x 10^8 Cells/ml.
2+ = 4 x 10^8 Cells/ml.
3+ = 6 x 10^8 Cells/ml.
4+ = 8 x 10^8 Cells/ml.
5+ = 12 x 10^8 Cells/ml.

In additional experiments not recorded here it was found that K_2HPO_4 in liquid mediums inhibits the growth of many CO_2-dependent strains of *Br. abortus*.

It should be said here that the growth of bacterial cells during the 3-day period had very little, if any, effect on the pH of the culture medium. The changes in the pH of the inoculated and uninoculated mediums (not recorded in the table) were approximately the same.

Results similar to those recorded in Table 1 were also obtained with tryptose and peptone M liquid mediums treated in the same manner, but visible growth was not apparent until the sixth day of incubation.

PROCEDURE AND RESULTS WITH WHOLE BLOOD

The blood specimens were collected in sterile concentrated sodium citrate, or were added to mediums containing the salt. The final concentration was 0.5 percent. In all trials, 5 ml. of blood was added to 20 ml. of medium in 50 ml. serum bottles. The pH adjustments recorded for each bottle of medium were made on a sample of the same quantity with 5 ml. of blood present. The bottles of medium were inoculated after adding the blood. At the end of the incubation period, the pH of the mixture in each bottle and the degree of multiplication of brucella cells were determined. The latter was determined by plating 0.5 ml. of the mixture on the surface of agar plates (pH 7.5) and incubating them in closed jars containing 5 percent CO_2. Duplicate agar plates incubated aerobically at the same time showed no growth.

The two principal factors found to inhibit the multiplication of brucella cells in liquid medium in the presence of blood were a) the bactericidal antibody-complement system and b) the glycolytic action of red cells by which glucose in the blood is degraded to organic acids.

Studies revealed that the presence of 2×10^9 killed brucella cells/ml. in the culture medium was sufficient to inactivate the brucella antibody-complement system in 5 ml. of animal and human blood. S-type cells were added to the medium just before autoclaving.

Aerobic and anaerobic glycolysis by red cells has been studied for many years (Melvin, 1912; MacLeod, 1913; Bird, 1947). When such glycolysis occurs in a culture medium to which blood is added, the pH may fall below that which is optimum for growth of brucella cells. However, by raising the initial pH with either $NaHCO_3$ or with Na_2CO_3, the formation of acid by the glycolytic action of red cells can be controlled and, also, this provides an excellent and simple means

TABLE 2—Effect of normal cow blood (*) and killed brucella cells on growth of a CO_2-dependent strain of Br. abortus in liquid medium (†)

Bottle No.	Medium + or −‡ killed cells	pH§ agent used	Inoc. cells added¶	Incubation, 72 hours at 37° C		
				Atmosphere	Growth **	pH of medium
1	−	7.1 None	10	Normal††	−	6.9
2	−	7.1 None	10	Sealed‡‡	−	6.9
3	−	7.1 None	25	5% CO_2§§	−	6.7
4	−	7.5 $NaHCO_3$	25	Sealed	−	7.4
5	+	7.3 $NaHCO_3$	10	Normal	−	8.2
6	+	7.3 $NaHCO_3$	25	Sealed	4+	7.1
7	+	7.5 $NaHCO_3$	25	5% CO_2	4+	7.1
8	−	7.4 Na_2CO_3	10	Normal	−	7.2
9	−	7.4 Na_2CO_3	10	Sealed	−	7.0
10	−	7.4 Na_2CO_3	10	5% CO_2	−	6.8
11	+	7.4 Na_2CO_3	10	Sealed	4+	7.0
12	+	7.4 Na_2CO_3	25	5% CO_2	2+	6.9
13	+	7.8 Na_2CO_3	10	Normal	−	7.8
14	+	7.8 Na_2CO_3	10	Sealed	4+	7.2
15	+	7.8 Na_2CO_3	25	5% CO_2	4+	6.9
16	+	7.8 NaOH	25	Normal	−	7.4
17	+	7.8 NaOH	25	Sealed	1+	7.1
18	+	7.8 NaOH	25	5% CO_2	1+	6.9

*5 ml. citrated blood added to each bottle of medium.
†Trypticase soy formula minus dibasic phosphate.
‡2 x 10^9 cells/ml. *Br. abortus* added before autoclaving.
§pH of medium after adding blood and agent.
¶Plate colony count.
** − = No growth, 1+ = $<10^2$, 2+ = $>10^3$, 4+ = $>10^5$ colonies/ml.
††Bottle closed with cotton.
‡‡Closed with rubber stopper.
§§Closed glass jar.

TABLE 3—Effect of normal human blood (*) and killed brucella cells on growth of a CO_2-dependent strain of Br. abortus in liquid medium (†)

Bottle No.	Medium + or −‡ killed cells	pH§ agent used	Inoc. cells added¶	Incubation, 72 hours at 37° C.		
				Atmosphere	Growth **	pH of medium
1	−	7.2 $NaHCO_3$	22-32	Sealed††	−	6.6
2	+	7.2 $NaHCO_3$	22-32	Normal‡‡	−	6.5
3	+	7.2 $NaHCO_3$	22-32	Sealed	4+	6.6
4	−	7.5 $NaHCO_3$	22-32	Sealed	−	7.1
5	+	7.4 $NaHCO_3$	22-32	Normal	1+	7.6
6	+	7.5 $NaHCO_3$	22-32	Sealed	4+	7.1
7	+	7.4 Na_2CO_3	22-32	Normal	−	6.8
8	−	7.4 Na_2CO_3	22-32	Sealed	−	6.7
9	+	7.4 Na_2CO_3	22-32	Sealed	4+	6.7
10	+	7.8 Na_2CO_3	22-32	Sealed	4+	7.0
11	+	8.0 Na_2CO_3	22-32	Sealed	4+	7.1

*5 ml. added.
†Trypticase soy formula minus dibasic phosphate plus 0.5 sodium citrate.
‡2 x 10^9 cells/ml. *Br. abortus* added before autoclaving.
§pH after adding blood or blood and agent.
¶Plate colony count.
**Closed with rubber stopper; ††Cotton plug.
‡‡− = No growth, 1+ = $<10^3$, 4+ = $>10^5$ colonies/ml.

of obtaining CO_2. The bottles of medium must be sealed after the addition of blood in order to retain the CO_2 that is released from the bicarbonate or carbonate and to obtain the optimum pH for growth.

A fresh solution of $NaHCO_3$ must be prepared and the required amount added to each individual bottle of medium after sterilizing. The bottle must be sealed after adding the bicarbonate. Its use is not practical for routine purposes.

When Na_2CO_3 is used, the pH should be adjusted to 7.5 before the medium is autoclaved. During autoclaving, the pH will rise to 7.9 - 8.0 which is near the optimum for glycolysis.

Representative results of the numerous experiments conducted with whole blood are recorded in Tables 2 and 3. The data in Table 2 show the effect of normal cow blood on the growth of CO_2-dependent

brucella cells; those in Table 3 illustrate the effect of human blood on growth.

It may be noted from the data presented in Tables 2 and 3 that in the presence of killed brucella cells and other optimum conditions there was rapid multiplication of the added living cells. In those bottles of medium (4-9-10, Table 2; 4-8, Table 3) in which no multiplication of cells occurred, the pH changes as a result of glycolysis or decomposition of bicarbonate were approximately the same as in the bottles of medium showing rapid growth. Therefore, the failure of the added cells to multiply in the absence of killed brucella cells cannot be attributed to the high initial or final pH of the medium.

When the pH of the medium was adjusted with NaOH to a point favorable for glycolysis, the added brucella cells failed to multiply to any extent, even though killed brucella cells were present. The failure to obtain rapid multiplication of cells in this medium cannot be accounted for at this time.

Experiments similar to those recorded in Tables 2 and 3 were performed with blood from five normal humans and two normal cows. At the end of 3 days' incubation, rapid multiplication of brucella cells occurred in the presence of whole blood only when killed brucella cells were present and when the pH of the medium had been adjusted with either $NaHCO_3$ (pH 7.3 - 7.4) or Na_2CO_3 (pH 7.8 - 8.0).

MEDIUM AND PROCEDURE RECOMMENDED FOR ISOLATION OF *BRUCELLA* FROM THE BLOOD OF INFECTED ANIMALS AND HUMANS

Culture Medium:

Trypticase	1.7 gm.
Phytone	0.3 gm.
NaCl	0.5 gm.
Dextrose	0.25 gm.
Sodium citrate	0.5 gm.
Distilled H_2O	100 ml.

Dissolve constituents at room temperature (20-25° C.). Adjust pH to 7.5 with 10 percent Na_2CO_3.

Add either killed or living *Br. abortus* cells to the extent of approximately 2×10^9/ml. of medium (see preparation of cells).

Distribute 20 ml. of medium into 50 ml. serum bottles. Plug with cotton. Autoclave at 120° C. for 20 minutes. When cool, replace cotton plugs with diaphragm rubber stoppers. During autoclaving the pH

of medium will rise to 7.9-8.0. Bottles of medium prepared as described will keep indefinitely.

Preparation of Brucella Cells for Use in Medium:

A large yield of cells may be obtained by growing a smooth strain of *Br. abortus* on the surface of either potato infusion or on peptone M agar containing 0.5 percent dextrose. One may add 1) the living cells directly to the freshly prepared medium, 2) the cells from a dense suspension killed by autoclaving (120° C. for 30 min.), 3) the cells from a dense suspension killed by the addition of ethanol to a final dilution of 40 percent. After treatment with ethanol for 10 minutes, the suspension should be centrifuged and the supernatant replaced with sterile distilled water. Suspensions of cells prepared by either of the latter two methods may be stored in the cold.

Direct Culturing of Blood:

With sterile syringe and needle, inject 5 ml. of blood through diaphragm stopper into the bottle of medium. Mix well. Cover the punctured stopper tightly with "Scotch" or adhesive tape to prevent leakage of CO_2 produced during incubation. Incubate at 37° C. At the end of each 3-day period, withdraw 0.5 ml. with syringe and needle and distribute over the surface of a trypticase soy or tryptose agar plate. Always seal punctured hole in stopper immediately after removal of sample from bottle to prevent loss of CO_2. Use agar medium adjusted to pH 7.5 if the plates are to be incubated in jars containing 5 percent CO_2. For aerobic growth, use the same medium at pH 7.1-7.3. The pH of the agar mediums should be adjusted with Na_2CO_3.

DISCUSSION

Although the data presented in this paper comprise only a part of those recorded in numerous experiments, they serve to illustrate the unfavorable conditions that retard and the favorable ones that promote the growth of a small number (10-50) of CO_2-dependent brucella cells in liquid culture medium without blood and in its presence. Additional data showing the effects of adjusting the pH of the medium to different levels with four agents and incubation in three different concentrations of CO_2 will be presented elsewhere.

Small numbers of certain fastidious strains of *Br. abortus* grow only under the conditions previously described. The procedure is also

just as satisfactory for the rapid growth of aerobic strains of *Brucella abortus*, *Brucella suis*, and *Brucella melitensis* as for the growth of CO_2-dependent strains of *Br. abortus*. It is reasonable to assume that the probability of isolating *Brucella* from the blood of infected animals or humans should be increased when the medium and conditions that have been found satisfactory for the growth of cells of fastidious strains of *Brucella* are used for routine blood culture.

The use of the procedure outlined herein eliminates the incubation of bottles of liquid medium and blood in CO_2 jars and the necessity of opening and closing them each time a specimen is sub-cultured for determining growth. Furthermore, the procedure furnishes a simple means for the physician or veterinarian to prepare a direct culture for shipment to the laboratory.

The addition of killed brucella cells or a water-soluble extract from cells to both liquid and agar culture mediums has another effect on the growth of *Brucella* equally as important as the inactivation of the bactericidal antibody-complement system. It was found early in this study that their addition to either liquid or agar culture mediums increased the growth rate of living brucella cells. The data pertaining to the growth-stimulating effect of brucella cells and a water-soluble extract from cells are presented in an accompanying paper.[1]

It has been the practice in certain laboratories to add bacteriostatic agents, such as crystal violet, to liquid medium for culturing blood in order to inhibit the growth of contaminating bacteria. This dye will also inhibit the growth of *Br. suis* and *Br. abortus* Type II (Wilson) and, therefore, should be omitted.

SUMMARY

The optimum conditions found essential for the rapid multiplication of small numbers of brucella cells in liquid culture medium in the presence of blood are as follows: 1) approximately 2×10^9 killed brucella cells/ml. should be present in the medium to inactivate the bactericidal antibody-complement system, 2) the pH of the medium should be adjusted to 7.9-8.0 with Na_2CO_3, 3) the culture bottle should be sealed after the addition of blood and during the period of incubation.

[1]Huddleson, I. Forest (1954). Effect of killed brucella cells and an extract from sonically disintegrated brucella cells in culture mediums on the growth of *Brucella abortus*. Mich. Agr. Expt. Sta. Quart. Bul. 37: 14-22.

The employment of the procedure described herein should eliminate the necessity of using sealed jars containing added CO_2 for culturing living brucella cells when present in blood.

LITERATURE CITED

Bird, R. M. (1947). Glycolysis in human blood. Jour. Bio. Chem., 169: 493-501.

Haring, C. H., and J. Traum (1937). Observations of pathogenic and antigenic effect of *Brucella abortus*. United States Bureau of Animal Industry, strain 19. Jour. Agr. Res., 55: 117-128.

MacLeod, J. J. R. (1913). Blood glycolysis: its extent and significance in carbohydrate metabolism. Jour. Bio. Chem. 15: 497-514.

Melvin, G. S. (1912). On glycolysis in blood. Biochem. Jour. 6: 422-428.

Stewart, B., B. Eddie, F. Paxton, and K. F. Meyer (1935). Bacteriological and serological findings in *Brucella abortus* infections in animals and man. California and Western Medicine, 43: 112-115.

EFFECT OF KILLED BRUCELLA CELLS AND AN EXTRACT FROM SONICALLY DISINTEGRATED BRUCELLA CELLS IN CULTURE MEDIUMS ON THE GROWTH OF *BRUCELLA ABORTUS*

By I. FOREST HUDDLESON[1]

DEPARTMENT OF BACTERIOLOGY AND PUBLIC HEALTH

DURING a study of factors influencing the growth of *Brucella abortus* in liquid culture mediums in the presence of blood[2], the investigator noted that the presence of killed brucella cells in the culture medium accelerated the rate of multiplication of the added live cells. As a result of this observation, experiments were initiated to determine to what degree the presence of killed brucella cells or an extract from sonically disintegrated brucella cells in agar mediums influenced colonial development following surface inoculation. The sterile extract was also added to different liquid culture mediums to determine its effect on the multiplication of cells of fastidious CO_2-dependent strains of *Br. abortus* classified as Type II (Wilson).

PROCEDURE

PREPARATION OF CELL EXTRACT

S-type *Br. abortus* cells were harvested from the surface of agar medium and suspended in sterile distilled water. The suspension was adjusted turbidimetrically to contain 10^{11} cells/ml. The sonic oscillator was adjusted to operate at 9 kc./sec. Thirty ml. of the suspension was placed in the treatment cell, cooled by flowing tap water, and sonic energy applied for 2 hours. The resulting opalescent liquid was then removed from the cell, centrifuged to remove cell debris and a small percentage of intact cells, and then sterilized by being heated in a water-bath for one hour at 65° C. One ml. of the extract represented approximately 10^{10} cells.

[1]The technical assistance of Rachel Bethea and Harold Redman is acknowledged.

[2]Huddleson, I. Forest (1954). Important factors influencing the growth of a CO_2-dependent strain of *Brucella abortus* in a liquid culture medium in the presence of blood. Mich. Agr. Expt. Sta. Quart. Bul. 37: 3-13.

ARTICLE 37-2

AGAR MEDIUMS

Three agar mediums, namely trypticase soy, tryptose, and peptone M, were used. They were either prepared from the manufacturer's pre-mixed powder or were made up in the laboratory from the constituents recommended. Either cells of an S-type culture of *Br. abortus* or a sonically prepared extract therefrom was added to the dissolved agar mediums just before autoclaving. After autoclaving, the H-ion concentration of each agar medium was determined and, when necessary, adjusted with *M* Na_2CO_3. Petri plates were poured and the surface was freed from water of condensation by incubation at 37° C. for 48 hours.

Suspensions of brucella cells of the strains used in the study were prepared from 24-hour agar slant cultures and were diluted to contain approximately 100 living cells/ml. One ml. of the suspension was flooded over the surface of each of three agar plates of each medium. As soon as the added liquid was absorbed by the medium the inoculated plates were incubated at 37° C. either aerobically or in jars containing 5 percent CO_2. At the end of 72 hours the mediums were examined to determine the number and diameters of the colonies present on the surface.

LIQUID MEDIUMS

Three liquid mediums, namely tryptose, trypticase soy, and peptone M, were prepared in the laboratory from the constituents recommended by the manufacturers. The mediums were distributed in 20 ml. amounts into 50 ml. serum bottles, which were closed with cotton plugs; the mediums were then sterilized by autoclaving. After being cooled to 20-25° C., each bottle of medium was inoculated with 15-20 living cells (determined from agar plate colony count) of a fastidious CO_2-dependent strain of *Br. abortus*. The bottles of medium were then divided into two groups; to one was added the sterile, faintly opalescent extract from sonically disintegrated cells. The other group served as a control. The mediums were adjusted to the desired pH levels with $NaHCO_3$ (0.9 *M* solution sterilized by filtration).

Immediately after the addition of the required amount of bicarbonate solution, the bottles were closed with diaphragm rubber stoppers and placed at 37° C. At the end of 48 and 72 hours each bottle of medium was examined for growth, as indicated by the degree of

turbidity. This was recorded as the approximate total number of cells/ml. The pH of each bottle of medium was determined (25° C.) at the end of 72 hours' incubation.

RESULTS

In order to determine whether the number of killed brucella cells in tryptose agar influenced the total colony count and size of colonies, five separate portions of agar were prepared, four of which contained different numbers of brucella cells. After sterilization by autoclaving, each portion was adjusted to pH 7.5 with Na_2CO_3 and poured into Petri plates. The agar surfaces of the plates were inoculated with one ml. of a suspension of a fastidious strain of *Br. abortus* and were then incubated as previously described under "Procedure."

The data in Table 1 show conclusively that when a sufficient number of killed brucella cells was present in tryptose agar, the number and the size of brucella colonies arising from the inoculum were considerably larger than those on the control medium. Only seven colonies appeared on the control medium, and these were nearly the size of brucella micro-colonies. The presence of 2×10^8 killed cells/ml. in the medium changed its growing property only slightly, whereas 2×10^9 or more cells/ml. resulted in a decided increase in the number and in the size of the colonies.

In one other experiment to determine the effect of killed brucella cells and that of the extract on colonial growth, three agar mediums and three S-type strains of *Br. abortus* were employed. Two of the strains were CO_2 dependent and one was non-CO_2 dependent. The results obtained with the three strains on the three mediums are shown in Table 2. The presence of either killed brucella cells or a sonic extract therefrom in agar mediums had little or no effect on the size attained by colonies of strains No. 1 and 2. These two strains were not fastidious in their growth requirements.

The type of medium, as well as the presence of brucella agents in the medium, had a decided influence on the development of colonies of strain No. 3. Colonies of this strain could not be seen on the three agar mediums (manufacturers' pre-mixed) at the end of 72 hours' incubation. It would appear that the mediums were deficient in a growth-promoting agent in view of the fact that bacterial colonies became visible when a sufficient number of killed cells or an extract therefrom was present. The number and the size of the colonies depended on the type of medium, the pH level, and the concentration

TABLE 1—Effect of different numbers of killed brucella cells in tryptose agar on colonial growth

Killed brucella cells added/ml.	Colonies*	
	No./plate	Diameter mm.
None	7	0.3
$2X10^8$	30	0.8
$2X10^9$	77	1.6
$5X10^9$	81	1.6
$10X10^9$	104	1.8

*Approximately 100 living cells added to agar surface. Medium adjusted to pH 7.5 with Na_2CO_3. Incubation at 37° C. for 72 hours.

of the brucella agent in the medium. It might be mentioned here that results similar to those recorded in Table 2 have been obtained with several pre-mixed lots of the same mediums when they were adjusted to the desired pH level.

While the tabulated data show the size attained by colonies of the CO_2-dependent strains in an atmosphere of only 5 percent CO_2, many parallel experiments were made with the same mediums in an atmosphere of 10 percent CO_2. The latter concentration of CO_2 lowered the pH level of the mediums below the optimum for rapid growth of colonies. Colonies of strain No. 3 were from 0.1 to 0.3 mm. less in diameter than those recorded in Table 2.

Other data not recorded here show that a medium of initial pH 6.9 decreases to 6.6 during incubation in 5 percent CO_2 and to 6.4 in 10 percent CO_2. One of initial pH 7.5 decreases to 7.1 in 5 percent CO_2 and to 6.9 in 10 percent CO_2. An initial pH of 7.1-7.3 has been found optimum for colonial growth of aerobic strains of *Br. abortus* and one of 7.5 for CO_2-dependent strains. For the production of large numbers of cells on agar mediums, the initial pH should be near 6.8 as alkaline metabolic agents produced during growth raise the pH within 24-48 hours of incubation to 8.0-8.4.

It was known from past experience that cells of the fastidious CO_2-dependent strain of *Br. abortus* did not multiply rapidly in tryptose and peptone M broth prepared according to the manufacturers' formulas and adjusted to different pH levels with either Na_2CO_3 or

$NaHCO_3$. Visible growth (turbidity) from the inoculum was not obtained in these two mediums during an incubation period of 72 hours in closed bottles or in an atmosphere of 5-10 percent CO_2.

Several experiments were conducted to determine whether the presence of the cell-free extract from brucella cells in tryptose broth

TABLE 2—Colonial growth of Br. abortus on different agar mediums containing 1) no additive, 2) extract of brucella cells, 3) killed brucella cells

Medium	pH adjustment agent used	Strain No.*		
		1†	2‡	3‡
		Colony diam., mm.		
Trypticase soy§	7.3 None	1.5	1.1	0
Trypticase soy¶	7.3 Na_2CO_3	1.8	1.0	0.6
Trypticase soy¶	7.5 Na_2CO_3	1.3	...	0.8
Trypticase soy(¶)+(**)	7.3 Na_2CO_3	1.8	1.1	1.5
Trypticase soy(¶)+(††)	7.3 Na_2CO_3	1.7	1.0	0.8
Trypticase soy(§)+(††)	7.3 None	1.8	...	0.4
Tryptose§	6.9 None	1.0	1.0	0
Tryptose¶	7.3 Na_2CO_3	1.8	1.2	0.2‡‡
Tryptose¶	7.5 Na_2CO_3	1.1	...	0.4
Tryptose(¶)+(**)	7.5 Na_2CO_3	...	1.3	1.0
Tryptose(¶)+(††)	7.3 Na_2CO_3	1.7	1.1	1.0
Peptone M§	6.8 None	1.5	...	0
Peptone M§	7.3	1.7	1.4	0.3‡‡
Peptone M§	7.5 Na_2CO_3	1.8	...	0.3‡‡
Peptone M(§)+(**)	7.3 Na_2CO_3	...	1.6	1.5
Peptone M(§)+(††)	7.3 Na_2CO_3	1.8	1.4	1.0

*Approximately 100 cells added to each agar plate.
†Aerobic strain. ‡Two CO_2-dependent strains.
§Mixed by manufacturer. ¶Mixed in laboratory.
**Extract from sonically treated brucella cells added.
††2 x 10^9 brucella cells added/ml.
‡‡Only 12-20 colonies seen.

TABLE 3—Concentration of extract from sonically treated brucella cells required to stimulate the growth of cells in tryptose broth

Bottle No.*	pH† adjustment	Amount of extract added‡	Inoc. cells added§	Incubation at 37° C.		
				Turbidity¶ hours		pH (72 hours)
				48	72	
1	None 6.8	0	30	—	—	6.8
2	7.2	0	30	—	—	7.5
3	7.2	0.1 ml.	30	—	—	7.5
4	7.2	0.2 ml.	30	—	2+	7.5
5	7.2	0.3 ml.	30	1+	3+	7.5
6	7.2	0.5 ml.	30	2+	4+	7.5

*20 ml. of medium in 50 ml. bottles; closed with rubber stopper after inoculation.
†pH adjusted with 40 mg. $NaHCO_3$ in solution after inoculation.
‡1 ml. of extract represents approximately 10^{10} cells.
§Plate colony count.
¶— = No turbidity; 1+ = 10^8; 2+ = 4×10^8; 3+ = 6×10^8; 4+ = 8×10^8 cells/ml.

accelerated the multiplication of cells of the strain of *Br. abortus* previously mentioned. Increasing amounts of a sterile extract representing from 10^9 to 5×10^9 cells were added to bottles of the medium (20 ml.) at the time of inoculation and adjustment of pH with $NaHCO_3$. The data in Table 3 show that the presence of a sufficient quantity of the brucella cell extract in tryptose broth has either a growth-stimulating effect on living brucella cells, or the extract added to the medium an agent which is otherwise absent and which the cells require for rapid multiplication.

The results presented in Table 4 further illustrate the effect of a sufficient quantity of the cell extract in three liquid culture mediums on the multiplication of cells of one fastidious strain of *Br. abortus*. Without the extract no visible growth was present in two of the liquid culture mediums at the end of 72 hours' incubation. On the other hand, when the extract was present, multiplication of a small number of living brucella cells occurred so rapidly that growth became visible within 48 hours provided other conditions, such as pH and CO_2 atmosphere, were favorable.

TABLE 4—Effect of extract from sonically treated brucella cells on growth of cells in different liquid mediums

Bottle No.*	Medium†	pH adjustment agent used‡	Inoc.§ cells added	Incubation at 37° C.		
				Turbidity¶ hours		pH (72 hours)
				48	72	
1	Tryptose	7.1 $NaHCO_3$	15	—	—	7.3
2	Tryptose+**	7.1 $NaHCO_3$	15	1+	4+	7.3
3	Tryptose	7.3 $NaHCO_3$	15	—	—	7.5
4	Tryptose+**	7.3 $NaHCO_3$	15	2+	5+	7.5
5	Trypticase soy	7.1 $NaHCO_3$	20	2+	4+	7.3
6	Trypticase soy+**	7.1 $NaHCO_3$	20	3+	5+	7.3
7	Trypticase soy	7.1 Na_2CO_3	20	—	—	7.2
8	Peptone M	7.2 Na_2CO_3	15	—	—	7.4
9	Peptone M+**	7.2 Na_2CO_3	15	2+	5+	7.3
10	Peptone M	7.4 Na_2CO_3	15	—	—	7.6
11	Peptone M+**	7.4 Na_2CO_3	15	1+	4+	7.5

*Bottles closed with rubber stopper after inoculation.
†Manufacturer's formula, 20 ml. in 50 ml. bottles.
‡Adjustment made at time of inoculation.
§Plate colony count.
¶ — = No turbidity; 1+ = 10^8; 2+ = 4 x 10^8; 3+ = 6 x 10^8; 4+ = 8 x 10^8; 5+ = 12 x 10^8 cells/ml.
**Extract from 5 x 10^9 cells, o.5 ml.

DISCUSSION

The inhibition of the growth of brucella cells in liquid culture mediums containing peptones has been noted and studied by Wright[3] and Schuhardt *et al.*[4] The previous studies were conducted with typical CO_2 non-dependent or dependent strains of *Br. abortus.* The findings of the investigators pointed toward a growth inhibition agent present in the peptones or formed in the medium during the autoclaving. The growth inhibitory action of the peptone was neutralized by the presence of various agents such as agar, glucose, liver extract,

[3]Wright, H. D. (1933). The importance of adequate reduction of peptone in the preparation of media for the pneumococcus and other organisms. Jour. Path. and Bact. 37:257-282.
[4]Schuhardt, V. T., L. J. Rode and G. Oglesby (1949). An antibrucella factor in peptones. Jour. Bact. 57:1-8.

and blood serum. The results of a later study by Schuhardt *et al.*[5] indicated that elemental sulfur produced in the medium as a breakdown product during autoclaving was responsible for the inhibition of the growth of brucella cells.

Since the growth of typical strains of *Br. abortus* was not inhibited on the culture mediums employed in this study, it is unlikely that an inhibitory agent was responsible for the delayed multiplication of cells of the fastidious strain. It would appear from the results of the experiments performed in this study that cells of this type of *Br. abortus* require, for their rapid multiplication in liquid and agar culture mediums, the presence of an agent that is present in brucella cells. Studies now in progress show that the growth-accelerating agent is not only present in brucella cells, but is demonstrable in cells of *Brucella bronchisepticus*, of *Micrococcus aureus*, in aged blood serum and in serum albumin. The studies that are being conducted to determine the chemical nature of the growth-accelerating agent in the extract from brucella cells reveal that the agent is either an albuminous substance or is associated with this fraction.

Multiplication of brucella cells occurred just as rapidly in trypticase soy broth without the cell extract as with it. Cell growth was visible in trypticase soy medium within 48 hours after inoculation. The presence of the extract from brucella cells in this medium increased the cell count 2-4 x 10^9/ml. above that obtained in the medium without the cell extract. It would appear that the medium contains constituents that are sufficient for the growth requirements of fastidious strains of *Br. abortus*. It should be emphasized that the addition of dibasic phosphate, now recommended by the manufacturer for the pH adjustment of this medium, should be omitted. Cells of the fastidious strain do not multiply rapidly when dibasic phosphate is present in either agar or liquid mediums.

The pH levels attained by the mediums after 72 hours of incubation were the actual ones under which the cells were growing during the entire period. These levels were reached within one hour after the bicarbonate solution was added. It has been noted during this study that cells of CO_2 dependent strains of *Br. abortus* multiplied rapidly within a pH range of 7.2-7.6 when the pH was adjusted with $NaHCO_3$ and other conditions for optimum growth were maintained.

It may appear paradoxical to many workers, as it did to the author in the initial stages of this study, that cells of CO_2 dependent strains

[5]Schuhardt, V. T., L. J. Rode, G. Oglesby and C. E. Lankford (1952). Toxicity of elemental sulfur for Brucellae. Jour. Bact. 63:123-128.

of *Br. abortus* multiplied rapidly in medium of pH levels above that which had been considered in the past as being optimum for rapid growth. Data to be presented in a later paper by the author will show that the multiplication of cells at various pH levels depends on the ratio of HCO_3/CO_2 in the medium during the period of incubation as well as other factors.

SUMMARY

The results of this study show that two agar mediums failed to meet the requirements for the colonial growth of a fastidious CO_2 dependent strain of *Br. abortus*. The two mediums that failed to support colonial growth were converted into highly satisfactory ones by the presence of a sufficient number of killed brucella cells or a cell-free extract therefrom. The growth of colonies was accelerated on the third agar medium by both agents.

Two of the three liquid culture mediums employed in the study failed to promote rapid growth of 50 or less living cells of the fastidious strain of *Br. abortus*. Rapid growth of cells was obtained in the mediums by the addition of a sufficient amount of an extract from sonically disintegrated brucella cells.

CORN SILAGE AS A SOURCE OF THE UNIDENTIFIED GRAIN FACTOR(S) NEEDED FOR MILK PRODUCTION

By C. F. HUFFMAN and C. W. DUNCAN
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MOST STUDIES dealing with the nutritive value of corn silage for milk production have been based on the partial or complete replacement of hay or hay-crop silage in a ration which already contained considerable amounts of grain. The literature and additional research pertaining to this subject have been reported recently by Huffman and Duncan.[1] These investigators concluded that the grain in corn silage contributes the unidentified grain factor(s) which is needed to balance the total digestible nutrients in roughage.

The purpose of the research reported in this paper was to determine the effect on milk production when part of the total digestible nutrients in an all-hay ration was replaced with corn silage.

EXPERIMENTAL

Eight Holstein cows were used in nine trials to determine whether corn silage contained the unidentified grain factor(s). The cows were maintained on an all-hay ration until they dropped markedly in milk production, and then part of the hay was replaced with corn silage on an equal total digestible nutrient basis. This depletion method makes it possible to test for the presence of the unidentified milk-stimulating factor(s) found in grains and some roughages. Most of the hays used in this work were either alfalfa or alfalfa-brome mixtures which supplied sufficient protein to meet the cows' requirements. Four different corn silages harvested in different crop years were used. The basal or depletion periods varied in length, but for comparative purposes, only the four 3-day periods immediately prior to the experimental

[1]Huffman, C. F., and C. W. Duncan (1954). The nutritive value of corn silage for milking cows. Jour. Dairy Sci. 37: (in press).

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period are included in this paper. All of the experimental periods in which corn silage was fed were at least 30 days in length.

Three-day composite milk samples were tested for butterfat, and the formula suggested by Gaines[2] was used for determining the pounds of 4 percent fat-corrected milk. The amounts of hay and corn silage consumed were recorded each day, and the cows were weighed every third day.

For comparative purposes, the amounts of fat-corrected milk produced, the body weights, and the amounts of hay and corn silage consumed were averaged for both the depletion and experimental periods.

RESULTS AND DISCUSSION

The amount of fat-corrected milk produced, the pounds of total digestible nutrients consumed, and the body weights of the eight cows during the depletion and experimental periods are illustrated graphically in Fig. 1. These data are average values. The cows consumed approximately 36 pounds of hay daily during the depletion period

[2]Gaines, W. L. (1928). The energy basis of measuring milk yield in dairy cows. Ill. Agr. Expt. Sta. Bul. 308.

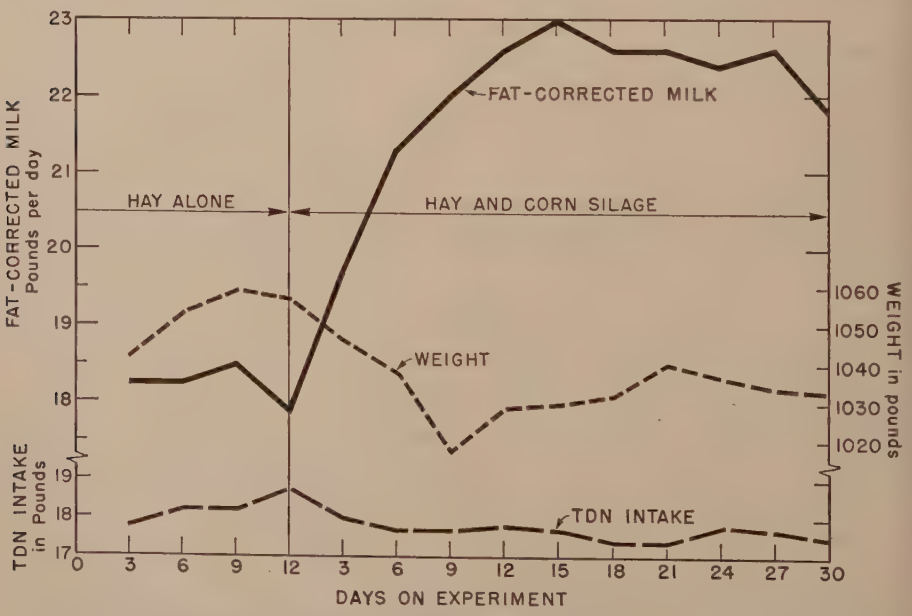

Fig. 1. The effect obtained on body weight and fat-corrected milk when part of the TDN (total digestible nutrients) was replaced in an all-hay ration with corn silage.

(range 30 to 40 pounds) and approximately 15 pounds per day during the experimental period (range 10 to 20 pounds). Corn silage consumption was approximately 55 pounds per day (range 42 to 75 pounds).

A marked increase occurred in the amount of fat-corrected milk produced when part of the hay was replaced with corn silage on an equal total digestible nutrient basis. The cows increased rapidly in milk production from about 18 pounds per day at the beginning of the experimental period to 23 pounds within the first 15 days (Fig. 1). Milk production reached a peak on the 12th day after silage had been added to the ration. This is in good agreement with results obtained previously by Huffman and Duncan[3] who reported that milk production reached a peak from the 9th to the 12th day after 9 pounds of corn replaced 15 pounds of hay in a ration of depleted cows. In the current study, milk production increased although the amount of total digestible nutrients consumed was somewhat less than that consumed during the depletion period. The cows had been producing milk for approximately 160 days when they were changed from the all-hay ration to the experimental ration.

A slight decline in body weight occurred after the cows were changed to the hay and corn silage ration, which may have been due to a small decline in dry matter consumption during the silage feeding period.

These data indicate that a pound of total digestible nutrients in a ration of hay and corn silage was more valuable for milk production than the same amount of digestible nutrients in an all-hay ration. These results, however, are not in agreement with the commonly accepted concept which Morrison[4] states in his summary of a review of the literature concerning the value of corn silage for dairy cattle: "In experiments with dairy cows, good corn silage has actually been worth 33 to 40 percent as much per ton as good legume or mixed hay. The feeding value of corn silage for dairy cows therefore agrees well with the amount of digestible nutrients it furnishes". Most of the previous experiments dealing with the value of corn silage for milk production were carried out with rations which already furnished enough grain to supply the milk-stimulating factor(s), therefore, the grain factor in corn silage could not manifest its true milk-producing value.

[3]Huffman, C. F., and C. W. Duncan (1949). The nutritive value of alfalfa hay: III. Corn as a supplement to an all-alfalfa hay ration for milk production. Jour. Dairy Sci. 32: 465-474.
[4]Morrison, F. B. (1948). *Feeds and Feeding.* 21st ed. The Morrison Pub. Co., Ithaca, N. Y.

The results of this experiment suggest that an allowance should be made for the amount of grain contained in the corn silage when feeding cows for efficient milk production. A previous report has shown (Huffman and Duncan[5]) that when fields of corn had been randomized just before ensiling, that each 7.5 pounds of good corn silage supplied 1 pound of U. S. No. 2 corn. In other words, a cow which consumed 55 pounds of this silage would obtain 7.5 pounds of corn grain.

CONCLUSIONS AND SUMMARY

Eight Holstein cows which had been depleted of their milk-stimulating factor(s) on an all-hay ration were used in 9 trials to determine the effect on milk production over a 30-day period when part of the hay was replaced with corn silage.

Milk production increased when corn silage replaced part of the hay although less total digestible nutrients were consumed.

The data show conclusively that the grain in corn silage contributes the unidentified grain factor(s) which is needed to balance the total digestible nutrients in an all-roughage ration.

[5]See footnote 1.

AN EXPLORATION OF POSSIBLE INCREASES IN FOOD CONSUMPTION

By LUTHER PICKREL and LAWRENCE WITT
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THE RE-EMERGENCE of agricultural surpluses has led to efforts at production controls. It has also encouraged consideration of alternative means of dealing with food surpluses.[1] Increased sales in the export market, greater industrial use, a larger number of feed consuming livestock and an increased human consumption all are alternative ways of dealing with feed and food surpluses, once produced. This paper is concerned with the latter point, i.e., *what are the potentialities for increased human consumption of food in the United States?*

There are a number of ways to evaluate possible expansion of food consumption. Much work has been done in terms of needed food elements for improved nutrition. Another approach is to consider the increases in consumption over time because of a larger population. Some of these effects have been popularized by the U. S. Department of Agriculture as "The Fifth Plate." Another method and the one used here is to consider how much of each of the various foods would be used if people in each income group consumed a little more than they now are consuming. Aggregating these changes provides percentage increases in total consumption of each food item.

To make this approach more relevant and not illogical as a possible goal, calculations were made using the level of consumption of the next higher income group as the measure of increase or decrease. The specific technique is as follows: For example, the average weekly consumption of dairy products in 1948 (milk equivalent, excluding butter) was 7.3 pounds per person in the group with family incomes under $1,000. Calculations were made, assuming that some kind of program was developed (income subsidies, food gifts, higher employment and wages, more consideration of nutrition, etc.) which brought

[1]The authors do not attempt in this paper to consider the question of "what is a surplus?".

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the level of consumption to 8.1 pounds—the average of those families in the $1,000 to $1,999 income group. Similar calculations were made for other income groups and other food groups.

Basic data were taken from *Food Consumption of Urban Families in the United States, Spring 1948.* Consumption was given by units (usually pounds) of the respective commodities by individuals in the various income groups. This consumption was then projected to the next higher group and the difference between the two multiplied by the number of persons in the lower group to determine the difference in per capita consumption. The differences were then totaled, and a calculation was made as to the percent this increase (or decrease) was of present consumption. Only those units receiving $7,499 or less were raised.[2]

[2]Income levels began at under $1,000, increased to $5,000 by increments of $1,000, from $5,000 to $7,500 and $7,500 and up.

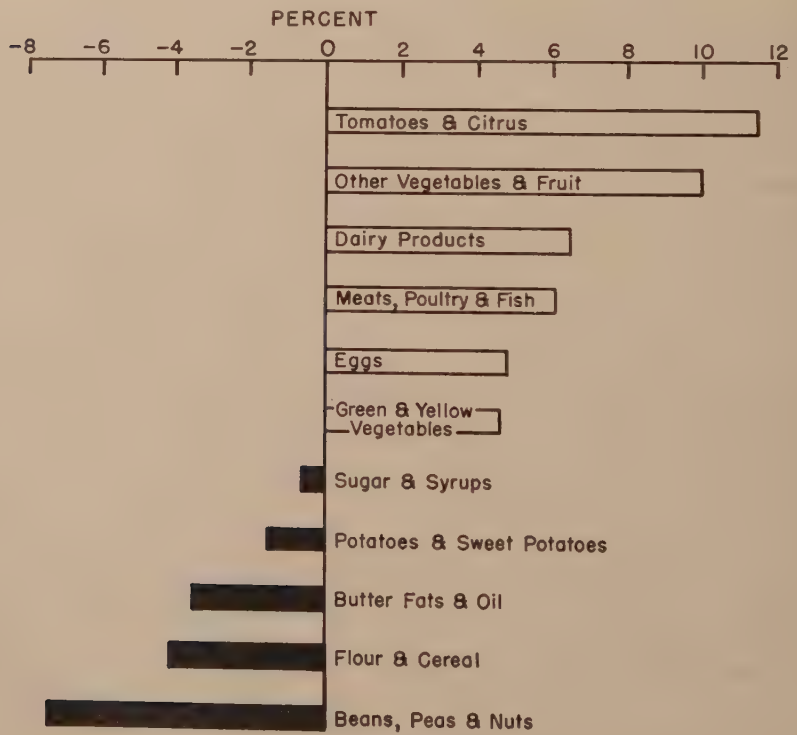

Fig. 1. Possible increases and decreases in total U. S. consumption by groups. (Derived by projectioning the consumption of each income level to that of the next higher income level. See Table 2.)

The major assumption implicit in this procedure is that if incomes in some way were raised or these additional food items were made available, any one lower income group would in fact take on the food consumption pattern of the next higher income group. In other words, it is assumed that low-income families do in fact prefer to eat more fruits and vegetables, meats and dairy products if they are available and would cut down on cereals and potatoes—as is shown by studies of food consumption patterns relative to income.[3] This assumption introduces some weaknesses, but it must be made if existing data are to be utilized. Another assumption is that the 1948 pattern of consumption does represent the pattern of relationships of a full employment economy and is generally applicable to later periods. Material from earlier consumer surveys of 1935-36 and 1942 was checked. The possible increases shown by these earlier data are similar but larger than those shown here. Lower incomes and unemployment in the 'thirties led to more careful buying and reduced food purchases in the depressed income groups.

This study, as indicated, is directed at gaging possibilities in the expansion of consumption; no attempt is made here to discuss possible methods of implementation. Figure 1, based on Table 2, summarizes the possible increases in consumption by food groups. The details and significance of these calculations are discussed below.

DIFFERENCES IN LEVELS OF CONSUMPTION

People with higher levels of income use different amounts of each kind of food product than do people with lower levels of income. While higher income groups spend more money for food, the amount usually is a smaller percentage of total income.[4] But all food products do not follow the same pattern. Some foods, such as dairy products, meats, fruits and vegetables constitute a larger share of the diets of higher income groups, while foods, such as cereals, fats and oils, are consumed at higher rates by the lower income groups. Table 1 shows the average consumption of various food groups in pounds per person per week for various income groups. It is based upon data collected in 1948.

It will be noted that the consumption of tomatoes and citrus fruits doubled from about 2.2 pounds a week per person in the lowest income

[3]The validity of this assumption can be checked as research results become available from the MSC consumer panel.

[4]These relationships have been known for many years and are commonly referred to as Engel's law.

group to about 4.4 pounds a week for the highest income group. The use of dairy products (excluding butter) increased from 7.4 pounds to 11 pounds a week. On the other hand, the use of flour and cereals dropped from 3.1 to 2.2 pounds a week per person, and the beans, peas and nuts group from 0.3 to 0.2 pounds per week.

The differences which exist in the levels of consumption may be due solely to income, or they may be the result of the kind of work done by people associated with each income group, or to the food habits and cultural backgrounds which these people have. Or the differences may be due in part to heavier food wastage by the higher income groups (which, if true, suggests that actual consumption for cereals, potatoes, etc., is even less than indicated by Table 1). Be that as it may, if each income group could be induced, on the average, to consume at the level of the next higher group substantial changes in national food use would occur, and many of these obviously would be in the direction of improved nutrition.

POSSIBLE INCREASE IN CONSUMPTION

Utilizing the differences shown in Table 1 and applying the percentage income distribution of the closest census of population (1950), the data shown in Table 2 were derived. These are all percentage

TABLE 1—Average quantity of various foods consumed by different income groups, United States, spring, 1948

	Under $1,000	$1,000-1,999	$2,000-2,999	$3,000-3,999	$4,000-4,999	$5,000-7,499	$7,500 up
	(Pounds per person, per week)						
Tomatoes and citrus	2.18	2.46	2.75	3.11	3.55	4.10	4.37
"Other vegetables and fruit"	2.40	2.69	3.24	3.71	4.10	4.18	4.39
Dairy products (except butter)	7.33	8.08	9.44	10.39	10.47	11.11	11.01
Meat, poultry and fish	2.32	2.43	2.63	2.94	3.04	3.23	3.35
Eggs	0.68	0.67	0.73	0.81	0.85	0.84	0.91
Green and yellow vegetables	1.97	1.77	1.86	1.94	2.35	2.28	2.50
Sugars, sweets	1.28	1.41	1.33	1.50	1.34	1.24	1.18
Potatoes and sweet potatoes	1.70	1.96	2.18	2.28	2.16	1.81	4.40
Butter, fats and oils	1.21	1.17	1.08	1.13	1.10	1.08	1.14
Grain (flour equivalent)	3.14	3.17	2.75	2.77	2.63	2.34	2.33
Dry peas, beans and nuts	0.31	0.36	0.28	0.27	0.23	0.22	0.20

Source: Computed from data given in Food Consumption of Urban Families in the U. S., Spring 1948, U.S.D.A., A.R.A., Bureau of Human Nutrition and Home Economics, Washington, D. C., Table 3, p. 8.

TABLE 2—Additional consumption possible if each income group consumed at the rate of the next higher group, by commodity

	Under $1,000	$1,000-1,999	$2,000-2,999	Sub total addition of lowest three groups	$3,000-3,999	$4,000-4,999	$5,000-7,499	Total addition
	(Percentage addition to total U. S. consumption)							
Tomatoes and citrus	1.9	1.5	2.2	5.6	2.9	1.7	1.3	11.5
"Other vegetables and fruit"	1.7	2.4	2.5	6.6	2.3	.3	.9	10.1
Dairy products (except butter)	1.5	2.2	1.9	5.6	.2	.9	− .1	6.6
Meats, poultry and fish	.8	1.1	2.1	4.0	.7	.9	.6	6.2
Eggs	− .2	1.2	1.9	2.9	1.0	...	1.2	5.1
Green and yellow vegetables	−1.9	.7	.8	− .4	4.0	− .4	1.6	4.8
Sugar and syrups	2.0	−1.0	2.3	3.3	−2.4	− .9	− .6	−0.6
Potatoes and sweet potatoes	2.6	1.6	.9	5.1	− .9	−2.1	− .5	−1.6
Butter, fats and oils	− .7	−1.2	.7	−1.2	− .3	− .2	1.9	−3.6
Flour and cereal products	.2	−2.0	.1	−1.7	− .9	−1.0	− .5	−4.3
Beans, peas and nuts	3.3	−6.1	− .5	−3.3	−3.3	− .5	− .5	−7.6
Millions of people in income group	29.44	22.22	28.00	...	30.24	18.72	22.08	...

Source: Computed from Table 1, U. S. Census of Population.

increases of total consumption in 1948. In other words, if the income group under $1,000 consumed 2.46 pounds of tomatoes and citrus instead of 2.18 pounds (as in Table 1), the increase multiplied by the number of people in this income group would mean an expansion of the total consumption of tomatoes and citrus fruit of 1.9 percent. If the $1,000 to $1,999 income group similarly increased their consumption from 2.46 to 2.75 (Table 1), then an additional 1.5 percent increase would occur. And if consumption in all income groups up to $7,499 were raised one notch, the total increase in consumption would be 11.5 percent. As indicated, this would involve consumption changes for 150 million people.

Under the assumptions made and with conditions comparable to those of 1948, the largest gains would be made by tomatoes and citrus fruit followed closely by "other vegetables and fruit" (green and leafy vegetables showing smaller increases). Dairy products (excluding butter), and meats, poultry and fish show an increase of about 6 percent, with eggs, and green and leafy vegetables averaging 5 percent.

The remaining items show decreases varying up to 7.6 percent, meaning that when people have larger incomes they choose to use less of these foods and more of other items. A note on the butter, fats and oils group is appropriate. The changes here appear to be due to

substantial drops in the use of fat pork which counteract the higher use of butter, other fats, and possibly of margarine in higher income groups.[5]

When one examines the details in the several income groups, it is evident that there is not a smooth pattern of changes. It is difficult to obtain accurate data with a large enough sample to provide stable interrelationships. Despite those shortcomings, it is evident that if efforts were concentrated on the lowest income group, more favorable results for potatoes and sweet potatoes, sugar and syrups, and beans, peas and nuts would be obtained than if all or several income groups were affected. For all groups, except green and leafy vegetables, more than half of the total increase would be obtained if efforts were concentrated on the income groups below $3,000. It is of interest that in the case of potatoes and sugar, positive rather than negative changes would be obtained. If only the third group ($2,000-$2,999) were considered, increases would be registered for all food groups, except beans, peas and nuts.

RELATION TO NUTRITION

It is evident that some of the changes in levels of consumption could lead to improved nutrition. The greater use of fruits and vegetables and dairy products would provide more protective elements in the diet. On the other hand, some food elements may already be available to some families in ample supply, and additions would really be unnecessary from the viewpoint of nutrition.

It must be remembered, however, that the higher consuming groups have freely purchased these larger quantities. The inference is that these foods were desired and that family welfare was improved (in their opinion) by the purchase of these foods.

While many detailed comparisons of food elements and food needs might be made, using the above-mentioned figures, there is an indication that these increased takings of food could in part be associated with improved nutrition.

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[5]Earlier studies have indicated a sharp rise in butter consumption as income increases (see *Consumption of Food in the United States*, 1909-1948, Misc. Pub. 691, p. 142) with per capita butter consumption in the highest group about two and one-half times that of the lowest group. However, more recent studies indicate only a very slight income-consumption relationship (see Moss, Thomas N., *Some Relationships of Selected Socio-Economic Factors to Food Consumption and Expenditures*, Lansing, Spring 1950. Ph.D. thesis, Michigan State College).

RELATION TO SURPLUSES

In direct relation to surpluses the data are much less favorable; only when surpluses are converted to livestock or the land diverted to other crops do the real potentialities of these changes begin to appear.

Increased consumption of food in general apparently means smaller consumption of cereals; potatoes; butter, fats and oils; beans, peas and nuts—all items which have accumulated in government stockpiles. Presumably increased income would force even larger quantities into government hands. The potential increased consumption of dairy products (excluding butter) if continued for one year, is about equal to the present government holdings of dairy products including butter. With some shift in the utilization of individual fats and oils, the potential consumption of dairy products may be even greater. Thus, only for dairy products would the increase in consumption immediately and directly result in smaller surpluses. Other products for which increases are indicated would show price increases as the first effect.

However, indirect changes via increased consumption of livestock and products would be the most important change, providing pricing and production policies were adjusted to facilitate the conversion of grains and feed to livestock products. Income from meats, poultry, eggs and dairy products now constitute more than half of the farm income. If consumption could be increased by 5 to 6 percent, it would require a substantial expansion not only in livestock but also in the feed crops for these animals. Previous work[6] suggests that a 1¾ to 2 percent change in livestock production would have prevented the accumulation of wheat and corn surpluses in the 'thirties and early 'forties.

To this should be added the small acreage shifts required for expanding production of fruits and vegetables. These obviously will be localized in special producing areas and around the large consuming centers, but in turn would require further shifts in other areas.

SUMMARY

As was indicated earlier, this article is concerned with estimating some of the consumption potentials of the people of the United States.

[6]Boger, Larry, and Arthur Mauch (1949). Corn bread or pork chops? Mich. Agr. Expt. Sta. Quart. Bul. 31: 363-369.

It is not concerned with possible means of implementation, be it subsidized consumption, advertising or other ways of expanding consumption.

The analysis of 1948 consumer purchases indicated that a stepping up of consumption levels to the next higher income group would lead to a 3.6 to 7.6 percent reduction in the use of potatoes; sweet potatoes; butter, fats and oils (as a group); flour and cereal products; and beans, peas and nuts. Little change would be expected for sugar and syrup. At the same time people apparently would increase their consumption of green and leafy vegetables; eggs; meat, poultry and fish; and dairy products by 4.8 to 6.6 percent, and of tomatoes and citrus fruits and the group designated as "other fruits and vegetables" by 11.5 and 10.1 percent, respectively.

A program striving to attain these consumption potentials would, at first, reduce only the government accumulation of dairy products. However, if price relationships were favorable to the conversion of wheat, corn and other crops to livestock and to the shifting of cotton, tobacco and wheat acreages to fruits, vegetables and feed crops, then government storage supplies of major crops could be reduced. There *is* a consumption potential for more than the probable production of livestock products, fruits and vegetables which would be forthcoming.

Implementation of such a program is not easy. To attain the levels of consumption shown in Fig. 1, about 85 percent of the population would need to use more food. A program affecting a smaller proportion of the people also would reduce the indicated additional food consumption. An imaginative and pervasive program of implementation would be required.

MICHIGAN FLORICULTURAL PRODUCTION

By HORST VON OPPENFELD

Department of Horticulture

Floriculture is an important segment of Michigan agriculture. Even though its returns do not compare with those from livestock farming, floriculture nevertheless provides a sizeable share of the returns from crop production.

Flowers are not one of the basic necessities of life. Flower buying is motivated by sentiment and, thus, in one sense floriculture is a luxury industry. In our economy of abundance luxury items, including flowers, are of increasing importance while the basic necessities command a lesser share of the consumer's dollar. The growth of floriculture indicates a rise in living standards.

Floriculture is the largest part of a group of allied agricultural enterprises, denoted horticultural specialties. For several decades information on the production of horticultural specialties has been compiled in connection with the Census of Agriculture. In recognition of the increasing economic importance of these crops the Bureau of the Census has issued a special report on horticultural specialties which presents detailed statistics on floriculture production in 1949. Comparable data for floriculture alone are not available from earlier census enumerations. However, the trends discernible for all horticultural specialty production are applicable to floriculture. In Michigan floriculture comprises two-thirds of all horticultural specialty production. The output of nurseries and bulb farms makes up the remaining third.

In studying floriculture it is well to pay some attention to the other segments of horticultural specialty production because the lines of demarcation between the groups are often blurred. Flowers, such as bedding plants, are often grown and sold by nursery establishments. Florists sometimes sell nursery products, such as rose bushes. Cut flowers and forced bulbs, typical florist products, are sometimes grown and sold in establishments classified as bulb farms.

ARTICLE 37-5

INCREASING IMPORTANCE OF HORTICULTURAL SPECIALTIES

During the past decades horticultural specialty production has shown a striking rate of growth. The number of United States farms engaged in horticultural specialty production increased from 30,000 in 1930 to 45,000 in 1950, an increase of 50 percent. This is even more significant when the concurrent decline in the number of all farms in the United States is considered.

More important than the increase in number of farms is the expansion in output of horticultural specialties relative to the value of all farm products. During the decade of World War I the production of horticultural specialty crops declined relative to the value of agricultural production (Fig. 1). Since 1920 sales of horticultural specialty crops have increased faster than sales of other farm products. During the last 10-year period, the rate of increase relative to the rest of agriculture has leveled off. Expansion has continued at about the same rate as for all farm production in the United States which increased sharply during this period.[1] Michigan's production of horticultural specialties has expanded more rapidly relative to Michigan agriculture, than that of the United States. This favorable rate of growth has continued during the past 10 years.

[1]Farm output index (1935-40) increased from 106 in 1939 to 140 in 1949. Source: U. S. Dept. of Agr., Bur. Agr. Econ. (1953). Agricultural Outlook Charts, 1954.

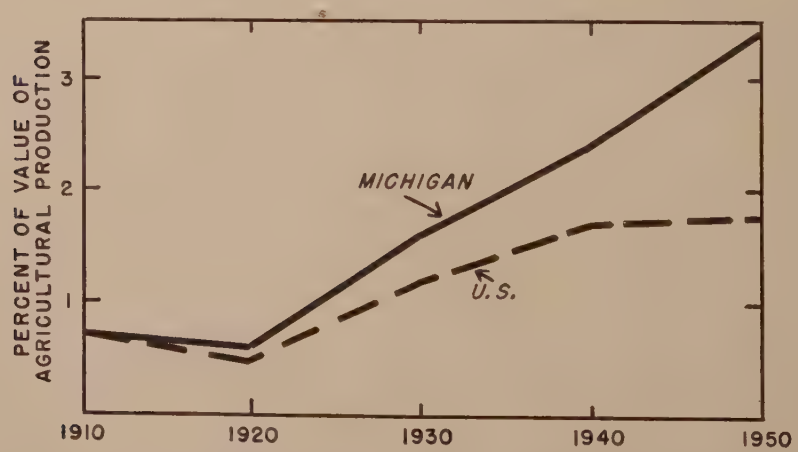

Fig. 1. Sales of horticultural specialty crops as a percentage of value of agricultural production.

Source: Fossum, M. T. (1953). Trade in horticultural specialties. U. S. Dept. Agr. Bur. Agr. Econ. Marketing Res. Rept. 33, p. 12.

At a time when surpluses of food and fiber staples are problems of public concern, farmers are looking for alternative opportunities to utilize their resources. The continuing growth of the horticultural specialty field in Michigan offers possibilities for some. Certain factors indicate a favorable rate of growth for years to come. The trend toward suburban development and outdoor living stimulates interest in flowers and plants for ornamental purposes. Home gardening is a favorite pastime for office and factory workers having leisure time. Gardening increases the demand for bedding plants, bulbs, and nursery crops. It makes people flower-conscious and develops a desire for out-of season flowers. Other favorable factors are the increasing population and the resulting expansion in construction of residential units.

COMMERCIAL PRODUCTION OF HORTICULTURAL SPECIALTIES

Establishments engaged in commercial production of horticultural specialties, excluding those reporting sales of less than $1,000, were enumerated in the Special Census of Horticultural Specialties. Only 952 establishments in Michigan qualified as commercial establishments (Table 1) in contrast to the 2,944 farms reporting sales of $150 or more of horticultural specialties.

*TABLE 1—Production of horticultural specialty crops, Michigan 1949**

	Establishments reporting	Crops valued at wholesale prices	
		Million dollars	Percent
Cut flowers and related plants	626	7.4	66
Nurseries	229	2.4	21
Bulbs	97	1.4	13
Total	952	11.2	100

*The Special Census of Horticultural Specialties did not include establishments reporting sales of less than $1,000.

Commercial establishments in Michigan produced a crop valued at $11.2 million in 1949. Cut flowers and related plants made up two-thirds of this total, and nursery products were 21 percent. Bulb crops, 13 percent of the total value, represented a larger share of all horticultural specialties in Michigan than in the United States. Michigan's crop grown in commercial establishments is the larger part of the

$15.9 million received for sales of horticultural specialties by all Michigan farms as enumerated in the general Census of Agriculture. The farm sales value is only $1.6 million below the $17.5 million, reported by the Census, for Michigan production of vegetables, other than potatoes, grown for home use and sale.

FLORICULTURE PRODUCTION IN TERMS OF WHOLESALE VALUES

Floriculture includes the production of field-grown and greenhouse flowers and plants, as well as annuals grown for replanting in gardens. It does not include perennial plants, trees and shrubs—generally considered nursery products—nor bulbs sold in dormant stage by bulb farmers.

For the 46 flowers and plants produced commercially in Michigan, output in terms of physical units is not comparable, because of the many crops and grades involved. The value of crops at wholesale prices appears to be the only practical measure of production.

To determine the share contributed by small and large establishments, Michigan's 626 producers were grouped according to wholesale value of crops produced. Four hundred and sixty establishments had a production of less than $10,000 at wholesale prices. One hundred and sixty-six larger units had a crop value of $10,000 and over.

The small units, almost three-fourths of all establishments, produced a crop valued at $1,659,559, less than one-fourth of all Michigan florist crops (Table 2). Large growers, on the other hand, constituting slightly more than one-fourth of the total number, delivered

TABLE 2—Wholesale value of Michigan's cut flowers and related plants, 1949

	Establishments with Crop Value of		State total
	Less than $10,000	$10,000 and over	
Establishments reporting	460	166	626
Value of all crops at wholesale prices	$1,659,559	$5,712,097	$7,371,656
Percent of establishments	73.5	26.5	100
Percent of crop value	22.5	77.5	100
Percent of U. S. output by respective group	5.2	3.1	3.4
Average value of crop per establishment	$3,608	$34,410	$18,997

over three-fourths of the state's crop. The smaller producers averaged a crop value of $3,608, in contrast to an average production by the larger units of $34,410 per establishment. The small greenhouse may not be an economic unit in itself, but its operation is continued by many retail growers who derive the larger share of their income from retail florist sales.

TABLE 3—Geographic distribution of Michigan floriculture and greenhouse vegetable production. 28 Major counties, crop value 1949, at wholesale prices

County	Establishments reporting		Crop value	
	Number	Percent	Dollars	Percent
Macomb	58	9	1,526,364	21
Wayne	65	10	1,182,575	16
Kent	56	9	615,574	8
Oakland	37	6	534,539	7
Kalamazoo	40	6	514,895	7
Berrien	17	3	334,808	5
Saginaw	21	3	318,652	4
Lenawee	13	2	242,159	3
Monroe	22	4	168,824	2
Washtenaw	15	2	141,865	2
Ottawa	23	4	129,598	2
Bay	14	2	129,026	2
St. Clair	12	2	119,433	2
Ingham	13	2	108,417	1
Muskegon	19	3	98,863	1
Jackson	9	1	86,711	1
Lapeer	4	1	82,888	1
Calhoun	11	2	72,889	1
Genesee	14	2	64,789	1
St. Joseph	5	1	59,262	1
Montcalm	5	1	54,887	1
Branch	8	1	54,685	1
Van Buren	11	2	50,241	1
Mecosta	4	1	45,931	1
Shiawassee	5	1	39,410	1
Mason	5	1	36,537	*
Eaton	5	1	34,701	*
Marquette	3	—	34,619	*
All Others	112	18	487,502	7
State total	626	100	7,371,656	100

*Less than 0.5 percent.

LOCATION OF MICHIGAN'S FLORICULTURE INDUSTRY

Commercial production of floriculture crops was listed by Census reports for 45 Michigan counties. For the 28 leading counties the number of establishments and the value of crops is summarized in Table 3.

The six ranking counties were Macomb, Wayne, Kent, Oakland, Kalamazoo, and Berrien. Together they had 43 percent of all commercial establishments and 64 percent of Michigan's floriculture pro-

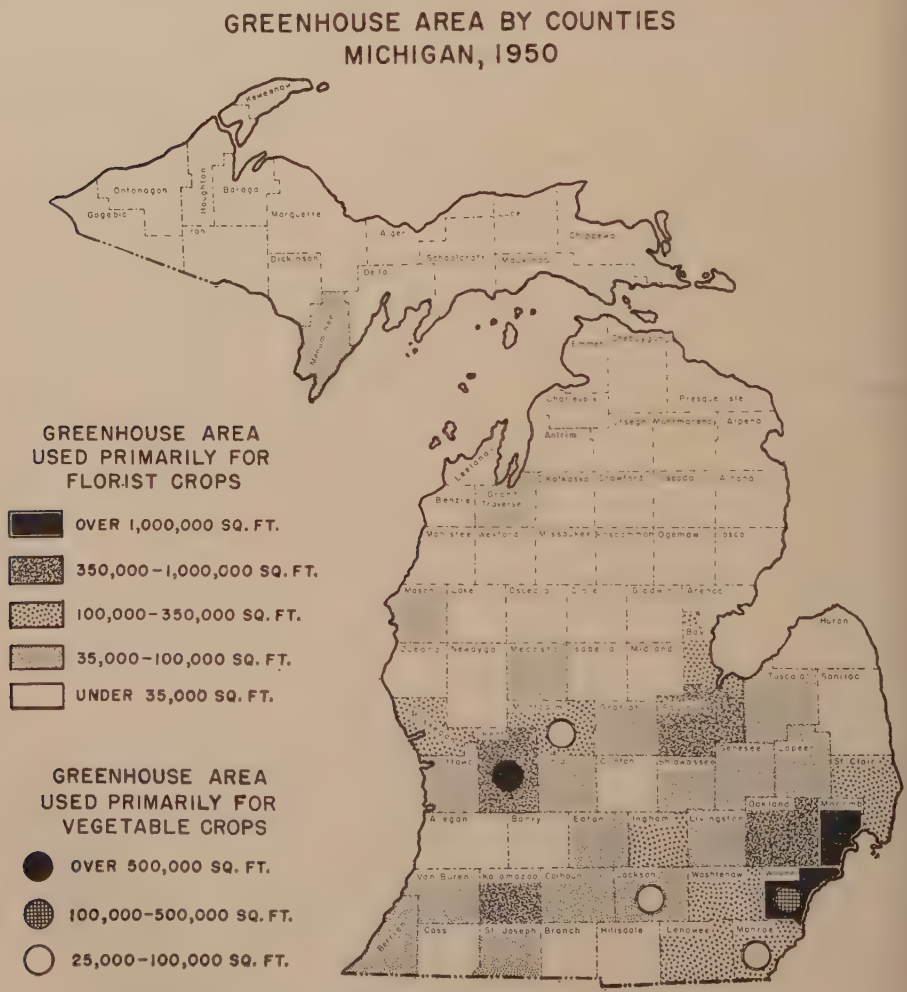

Fig. 2. Greenhouse area by counties in Michigan, 1950.

duction. Primarily these counties serve the metropolitan markets of Detroit, Grand Rapids, and Kalamazoo. Berrien County is fairly close to the Chicago market area.

The concentration of floriculture production is further illustrated by the county map of greenhouse area (Fig. 2). Macomb County, only third in total greenhouse area, ranked first in crop value. Two-thirds of this value came from greenhouse roses sold as cut flowers. Wayne County had the largest greenhouse area and was second in value of production.

Kent County had more greenhouse area than Macomb County, and was the leading county in greenhouse vegetable production. However, the combined value of vegetables and flowers produced was less than half the crop value of either Macomb or Wayne County.

Greenhouse area for vegetables under glass is shown in Fig. 2 because many greenhouses, originally built for hot-house vegetables, have been converted to flower production. In other greenhouses vegetables and flower crops are alternative enterprises.

In both Fig. 2 and Table 3 one relationship stands out: namely, production facilities tend to be located in or near population centers. This is a natural location for enterprises producing highly perishable products.

However, technological progress in transportation and refrigeration tends to shift the production of cut flowers to areas of favorable climatic conditions. Many Michigan greenhouse operators have met the competition from out-of-state cut flowers by shifting to bulky products, such as potted plants and bedding plants for which nearness to market is a distinct advantage.

WHOLESALE AND RETAIL SALES OF CUT FLOWERS AND RELATED PLANTS

Commercial growers in the United States received $321 million for their 1949 production of cut flowers and related plants (Table 4). Wholesale sales were a more important source of income to flower growers than retail sales. Fifty-nine percent of the total came from wholesale sales and 41 percent from retail sales. The two main types of wholesale sales were those made directly to retail outlets and to other wholesale establishments. In the United States the larger portion of wholesale sales was made through wholesale trade channels. In Michigan the pattern was reversed, the growers receiving 57 percent

TABLE 4—Growers' sales of cut flowers and related plants, United States and Michigan, 1949

Growers' sales	Sales in million dollars		Percent of total sales	
	United States	Michigan	United States	Michigan
Sales to wholesale establishments.	108	2.4	34	18
Sales to retailers.....	81	3.4	25	25
All wholesale sales.....	189	5.8	59	43
All retail sales.....	132	7.7	41	57
Total sales.....	321	13.5	100	100

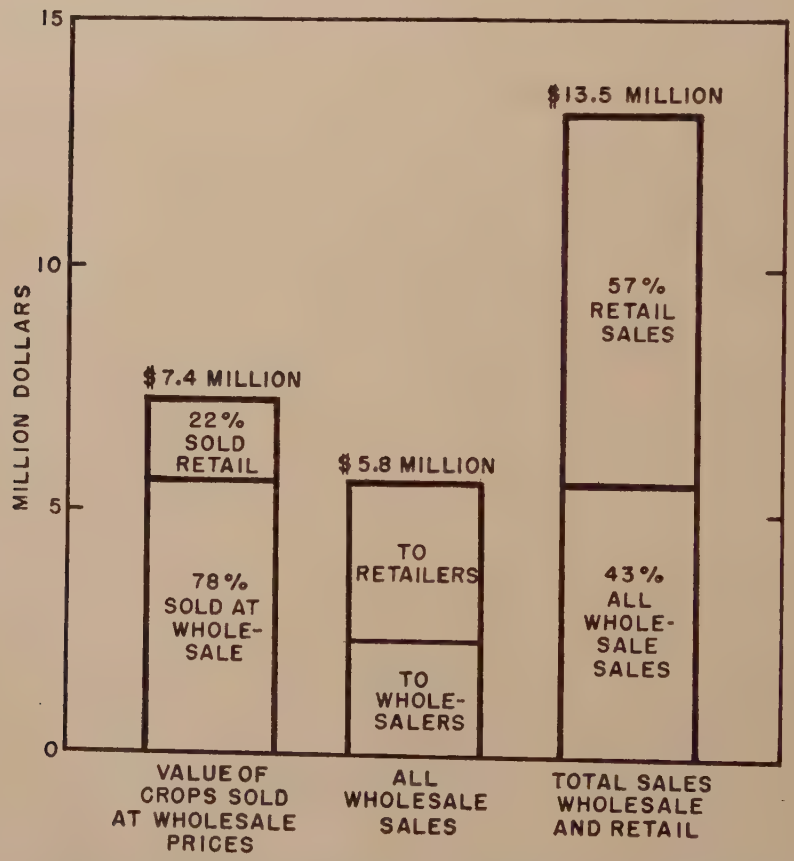

Fig. 3. Crop value, wholesale sales, and retail sales of Michigan growers, 1949.

of their sales income from retail sales. They also made less use of wholesale channels. The larger share of their wholesale sales went directly to retailers.

The relationship between floriculture crops produced and growers' total sales is illustrated in Fig. 3. In 1949 Michigan's floriculture production was valued at $7.4 million at wholesale prices. Seventy-eight percent of this crop was sold at wholesale. The remaining 22 percent was sold directly to consumers by retail growers, a proportion which seems surprisingly small if one considers the fact that 405 of Michigan's growing establishments combined a retail business with the growing operation. These retail growers reported retail sales of $7.7 million. Only $1.6 million of their retail sales was accounted for by the wholesale value of flowers produced in their own establishments. Aside from the normal retail mark-up, the balance consisted of purchased flowers and other goods and services bought for resale.

The center column in Fig. 3 shows the division of the $5.8 million of wholesale sales. The largest part was sold directly to retailers. The right-hand column represents Michigan growers' combined wholesale and retail sales, totaling $13.5 million. Michigan-grown floriculture crops, valued at $7.4 million at wholesale prices, constituted 54 percent of the growers' total sales and only 21 percent of the $30.3 million volume handled by all retail outlets in Michigan.

TABLE 5—Michigan growers' sales of cut flowers and related plants, 1949 by large and small establishments

	Establishments with crop value of		All establishments
	Less than $10,000	$10,000 and over	
All Wholesale Sales			
Establishments reporting	321	145	466
Sales	$ 996,151	$4,825,471	$5,821,622
Average per establishment	3,103	33,279	12,493
All Retail Sales			
Establishments reporting	310	95	405
Sales	$3,713,781	$3,979,996	$7,693,777
Average per establishment	$11,980	$41,895	$18,997
Total Sales			
Establishments reporting	460	166	626
Sales	$4,709,932	$8,805,467	$13,515,399
Average per establishment	$10,239	$53,045	$21,590

Note: Some growers reported both wholesale and retail sales.

The share of income which large and small establishments received from wholesale and retail sales is shown in Table 5. Retail sales were the major source of income for the small grower. For all small establishments together, retail sales were just under four-fifths of the total sales and wholesale sales a little over one-fifth. The larger establishments obtained a greater portion of their gross income from wholesale sales.

The larger establishments had over four-fifths of all wholesale sales. In this group the 145 producers selling at wholesale averaged $33,279 per establishment. The 321 small growers reporting wholesale sales averaged only $3,103 each.

The volume of retail sales, on the other hand, was almost equally divided between the small and large establishments. Ninety-five large producers engaged in retail sales had an average volume of $41,895. Retail sales of the 310 small units averaged $11,980 each.

EXPENDITURES, EMPLOYMENT AND CAPITAL INVESTMENT

In addition to the output information in terms of sales and crops at wholesale value, Census enumerators collected data on various input factors. The expenditures of 626 Michigan growers are summarized in Table 6.

The growers spent the largest share (63 percent) of their specified expenditures in wages and salaries to paid employees and officers of corporations. Coal, oil, and gas for heating together represented the next highest expense item, or 15 percent of all specified expenses.

TABLE 6—Specified expenditures of establishments producing cut flowers and related plants, Michigan, 1949

Expense item	Establishments reporting	Amount	Average per establishment
Wages and salaries paid to:			
1. Officers of corporations	24	$ 325,008	$13,542
2. All other paid employees	462	3,080,635	6,668
Manure and fertilizer	609	190,982	314
Fungicides and insecticides	589	67,980	115
Seeds, plants, bulbs for planting	599	735,009	1,227
Coal—63,504 tons	468	683,876	1,461
Fuel oil—1,446,511 gallons	73	121,568	1,665
Gas for heating	9	3,831	426
Advertising	508	161,548	318
Total	626	$5,370,437	$8,579

TABLE 7—Employment in establishments producing cut flowers and related plants, Michigan, 1949

	Establishments reporting	Persons	Percent of total
Proprietors (unincorporated).....	598	761	24
Unpaid family workers.....	309	491	16
Paid officers (corporations).....	24	69	2
Other paid employees (March 15)*	386	1821	58
Total employment†.....	.....	3142	100

*Sixty percent of all other paid employees worked on a year-round basis.
†Total employment was about equally divided between small and large establishments (52 percent working in establishments with a crop value of less than $10,000).

Seeds, plants, and bulbs for planting made up another 14 percent of the expenses. Remaining expenditures in order of their importance were 1) manure and fertilizer, 2) advertising, and 3) fungicides and insecticides.

The list of itemized expenditures is not necessarily complete and all-inclusive. Furthermore, as greenhouse operation and the retail business are frequently overlapping functions of the individual florist and his employees, the separation of a retail grower's expenditures into growing and selling expenses is not an easy task. Few retail growers keep separate accounts for their growing and retail operation. It should also be noted that charges have not been made either for depreciation of structures and equipment or for interest on the investment. Nevertheless, an understanding of the kind and proportion of expenses involved in commercial flower production may be gained from the list of specified expenditures.

As wages and salaries were by far the most important input factor, it is evident that flower production is highly intensive in the use of labor. Mechanization has not replaced labor to the extent observed in many other types of farming.

The importance of labor as the highest cost factor is further illustrated by a look at the florists' labor force. One-fourth of the 3,142 persons engaged in Michigan's floriculture production consisted of self-employed proprietors in unincorporated business units (Table 7). Unpaid family workers made up another 16 percent of all workers. Family labor, including both the operators and unpaid family labor, supplied 40 percent of the total labor force. Compensation for their efforts in labor and management was not included in the amount listed under wages and salaries in Table 6.

Fixed assets, including the value of land, structures, and equipment, represented another important input factor. Investment in land, structures, and equipment totaled $13 million for the 626 Michigan florists (Table 8), or an average of $20,797. With the 1949 crop having a wholesale value of $7.4 million, an output of 1.8 years would be required to produce the equivalent amount invested in land, structures, and equipment.

The larger establishments, representing 58 percent of the total amount invested in land, structures, and equipment, produced 65 percent of the total value of the crop. With an average investment of $45,775 per establishment, their output in a period of only 1.3 years would equal the capital investment in fixed assets.

The small units had an average of $11,783 invested in land, structures, and equipment and produced crops having an average annual value of $3,608. At that rate the output of 3.3 years would be required to equal the value of land, structures, and equipment. Small establishments were less efficient in the use of capital than were the larger units.

IMPORTANCE OF INDIVIDUAL FLORIST CROPS

Before the advent of modern transportation, refrigeration, and other marketing facilities, a small town florist depended primarily on his own greenhouse or range to supply the flowers and plants his

TABLE 8—Relationship of capital investment in land, structures, and equipment, to value of output, Michigan floriculture establishments

	Establishments with crop value of		All Michigan establishments
	Less than $10,000	$10,000 and over	
Establishments reporting	460	166	626
Value of land, structures, equipment, 4/1/50.	$5,420,134	$7,598,644	$13,018,778
Value of 1949 crop at wholesale prices	1,659,559	5,712,097	7,371,656
Percent of Michigan Total			
Value of land, structures, equipment	42	58	100
Value of 1949 crop at wholesale prices	35	65	100
Average per establishment			
Value of land, structures, equipment, 4/1/50.	$11,783	$45,775	$20,797
Value of 1949 crop at wholesale prices	3,608	34,410	11,776
Years required for output to equal investment in land, structures, equipment	3.3	1.3	1.8

TABLE 9—Value of flowers grown in Michigan, wholesale value, 1949

Classified crops	Dollars	Percent classified crop is of:	
		Michigan total	United States total
Plants, rooted cuttings, etc. sold for growing on.	1,470,457	23	16
Cut flowers grown under glass	2,944,796	45	49
Potted plants grown under glass	1,618,426	25	19
Cut flowers grown under cloth	86,809	1	2
Crops grown outdoors and under lath	423,471	6	14
All flowers	6,543,959	100	100

customers demanded. Increasing specialization is possible through the exchange of crops and specialties in the market. It is of interest to note the share held by classified crops in Michigan's commercial floriculture production (Table 9).

Cut flowers grown under glass, valued at almost $3 million, accounted for 45 percent of all floriculture crops in Michigan and were by far the most important of five classified flower crops. Potted plants grown under glass held second place with 25 percent. Third in value of classified crops were plants, rooted cuttings, etc., sold for growing on, representing 23 percent of the total value.

The relative importance of classified crops can be appraised by a comparison of their percentage share in Michigan and in the United States. Cut flowers grown under glass and under cloth, as well as crops grown outdoors and under lath, were relatively less important in Michigan than in the United States.

Michigan's production, on the other hand, exceeds the United States percentage in two classified crops, plants, rooted cuttings, etc., sold for growing on, and in potted plants grown under glass. Production of plants and rooted cuttings is generally carried on in specialized establishments. The light weight of small plants facilitates shipments across state borders. The percentage of plants and rooted cuttings sold by Michigan's establishments indicates that a greater value of plants and rooted cuttings, sold for growing on, is shipped out than is imported into Michigan. Michigan's leading position in potted plants, grown under glass is partly explained by the bulkiness of this product. Importation of potted plants is small.

As a point of reference it may be noted that Michigan had 4.2

percent of the United States population and 4.6 percent of retail floriculture sales. Having only 3.4 percent of the nation's flower crops, Michigan was far from self-sufficient in flower production. In respect to crops which they can produce as cheaply as their competitors in other states, Michigan growers have a sizeable potential market.

Flowers and greenhouse vegetables are alternative enterprises for greenhouse operators. Few physical changes in plant structure and equipment are necessary if the operator decides to change from one to the other. Some greenhouse men produce both flowers and vegetables in the same rotation. It is of interest to know the relative returns that may be expected from each of these two enterprises.

A wide disparity existed between returns from florist crops and those from greenhouse vegetables. The value of crops per square foot of glass averaged 94 cents in those Michigan establishments used primarily for florist crops (Table 10). This was more than twice the return from vegetables grown under glass. The same relationship was evident for all United States production.

Although small units in Michigan received an average return as high as the average for all small establishments in the United States, the larger growers of the state were far ahead in value of crops produced per square foot of glass. These larger establishments, however,

TABLE 10—Average annual value of crops at wholesale prices per square foot of greenhouse area, United States and Michigan, 1949*

	Average crop value in cents per square foot		
	Establishments with crop value of		All establishments
	Less than $10,000	$10,000 or more	
United States:			
Establishments used primarily for:			
Florist crops	62	112	101
Vegetable crops	35	50	48
All establishments	59	102	93
Michigan:			
Establishments used primarily for:			
Florist crops	64	107	94
Vegetable crops	34	42	40
All establishments	60	97	87

*To get the equivalent sales per square foot of bench space all figures should be increased by approximately 50 percent.

TABLE 11—Ten leading Michigan crops of cut flowers and related plants, valued at wholesale prices, 1949

Classification and crop	Establishments reporting	Crop value, dollars	Percent of state total
Plants, rooted cuttings, etc.			
Geraniums	279	374,400	5.1
Bedding and vegetable plants	356	981,712	13.3
Cut flowers grown under glass			
Roses	17	1,172,808	15.9
Chrysanthemums (Pompons)	275	478,871	6.5
Carnations	197	442,525	6.0
Potted plants grown under glass			
Poinsettias	152	271,822	3.7
Foliage and green plants	150	327,288	4.4
Vegetables and mushrooms grown under glass			
Tomatoes	41	266,295	3.6
Propagated mushrooms	8	408,680	5.5
Cut flowers grown outdoors and under lath			
Gladiola flowers	136	307,678	4.2
Ten leading crops		5,032,079	68.2

did not equal the average United States production per square foot for all large commercial growers.

The Census of Horticultural Specialties provides production data for 46 individual florist crops grown in various Michigan counties and summarizes the production of additional crops under the heading "other crops." In view of the variety of crops produced, it is significant that the 10 leading crops accounted for 68 percent of Michigan's total floriculture production (Table 11).

Roses grown under glass and sold as cut flowers represented 16 percent of the value of all commercially grown florist crops. Although produced in only 17 Michigan establishments, roses ranked as the number one crop and were far more important in terms of value than any other individual flower or plant.

In second place was the combined value of bedding and vegetable plants. The other leading crops, ranked in order of value, were pompon chrysanthemums, carnations, propagated mushrooms, geranium plants or cuttings, foliage and green plants, gladiola grown outdoors and sold as cut flowers, poinsettias, and greenhouse tomatoes.

The small number of establishments engaged in growing roses and the limited number of those growing mushrooms are evidence of a

high degree of specialization. The large output per establishment indicates the large scale production. In contrast, more than half of all Michigan establishments reported production of bedding and vegetable plants. Almost half of the commercial growers produced geranium plants or cuttings, sold for growing on, and pompon chrysanthemums.

SUMMARY

Michigan floriculture production was concentrated around the metropolitan markets. The six leading counties produced 64 per cent of the state's output of cut flowers and related plants. Macomb County ranked first in crop value. Wayne County had the largest greenhouse area and was second in value of production.

Almost three-fourths of Michigan's commercial flower growers were relatively small-scale producers, with crops valued at less than $10,000 per establishment. Almost four-fifths of their total sales consisted of retail sales to consumers. Wholesale sales of flowers were only a small share of their income.

Small units, nearly three-fourths of all establishments, produced less than one-fourth of Michigan's total crop of cut flowers and related plants. They averaged an output at wholesale prices of $3,608 and an investment in land, structures, and equipment of $11,783. A period of 3.3 years would be required for the output to equal the capital invested in fixed assets. The larger establishments averaged $45,775 in fixed assets. Their output would equal the investment in land, structures, and equipment in a period of 1.3 years. These larger units were more efficient in their use of capital.

Cut flowers grown under glass accounted for 45 percent of Michigan's floriculture production. The most important individual crop, 16 percent in value of all florist crops, was roses, grown in only 17 Michigan establishments. In general, Michigan's floriculture industry was specialized in the production of relatively few crops. The 10 leading crops together made up 68 percent of all Michigan production. The average returns per square foot of glass were twice as high from flowers as from greenhouse vegetables.

SOURCES

Data pertaining to horticultural specialty crops have been compiled both from the 1950 Census of Agriculture[2] and from the 1948 Census of Business. Trade statistics were integrated, analyzed, and published in a special marketing research report.[3]

Certain limitations are inherent in the Census data. First, the information collected for the 1950 Census of Agriculture covers the business year of 1949. By the time the figures were published, many changes may have occurred. Second, data presented by the 1950 Census of Agriculture are not comparable to information available from the special census of horticultural specialties. The Census of Agriculture included small-scale and part-time farms, producing $150 worth of crops or more. The special census enumeration excluded all units reporting sales of less than $1,000 in 1949. Third, the Census figures are based on information submitted by individual producers. Certain inaccuracies may have resulted from faulty reporting.[4]

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[2]United States 1950 Census of Agriculture, Volume V, Special Reports, Part 1, Horticulture Specialties, 1952.

[3]Fossum, M. T. (1953). Trade in horticultural specialties. U. S. Dept., Bur. Agr. Econ. Marketing Research Rept. 33.

[4]Prof. Paul R. Krone, who has served many years as an extension specialist and has worked with most Michigan florists in their organizations, is thoroughly acquainted with Michigan's florist industry. It is his considered opinion that there has been considerable under-reporting, particularly of crops produced by retail growers who keep no separate accounts for greenhouse and retail operation.

RETAIL DISTRIBUTION OF FLORICULTURAL CROPS IN MICHIGAN

By HORST VON OPPENFELD

Department of Horticulture

In contrast to flower growing, which is a type of farming, retail floriculture is a combination of retail and service trade. Retail florists grow or buy flowers and plants for resale to consumers. The services they provide with the merchandise, such as designing, display, delivery and credit extension, are important contributions to the usefulness of floriculture products.

The service function has necessitated a higher rate of markup for flowers than for other perishable merchandise. It may have limited the sales volume in individual retail florist outlets. Eighty-one percent of all retail florist trade in 1949 was carried on by establishments with less than $100,000 annual sales. Contrary to other retail businesses, the organization of extremely large units or the development of chain store outlets has not proved feasible for the retail florist trade. Family operation still predominates in retail flower shops.

The retail florist trade includes three types of establishments:

1) **Retail florists,** primarily engaged in selling, at retail, cut flowers and potted plants and rendering services incidental to the sale of these goods;

2) **Retail growers,** engaged in production of floriculture crops as well as retail selling of commodities grown and purchased;

3) **Other retail floriculture outlets,** such as vendors and establishments, other than retail florists or retail growers, engaged in merchandising goods and services to consumers.[1]

Statistics on retail florists and other retail floriculture outlets were assembled from the 1949 Census of Business, those on retail growers from the 1950 Census of Agriculture.

[1]Definition of retail florist trade adapted from M. Truman Fossum (1953). Trade in horticultural specialties. U. S. Dept. Agr., Bur. Agr. Econ. Marketing Research Rept. 33, pp. 103-104.

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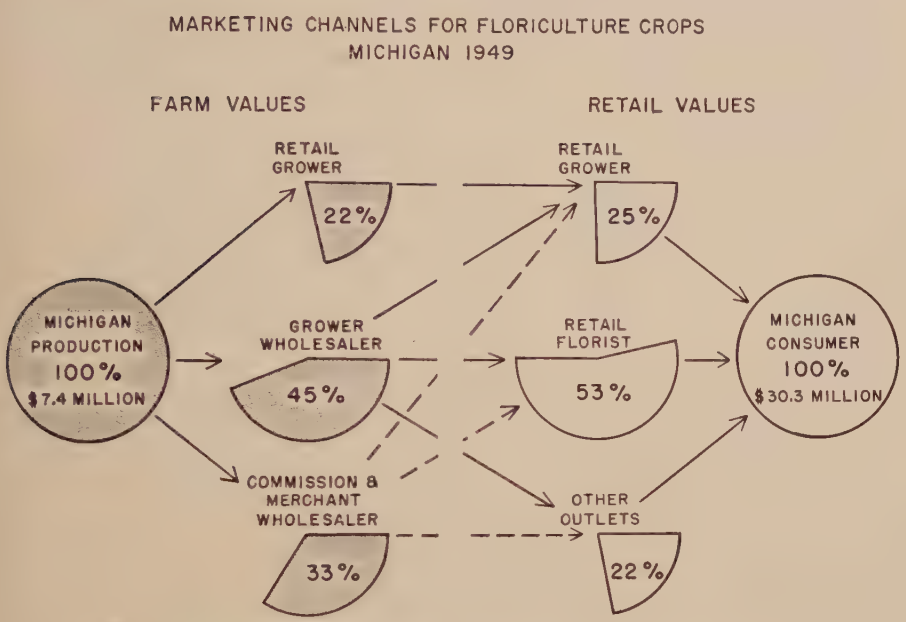

Fig. 1. Marketing channels for floriculture crops, Michigan, 1949.

MARKETING CHANNELS FOR FLORICULTURE CROPS

The integration of floriculture production, trade, and consumption in Michigan is illustrated by the diagram (Fig. 1). The left half of the diagram deals with farm values (values at wholesale prices); the right half of the diagram lists retail values.

Michigan's floriculture production was valued $7.4 million at wholesale prices in 1949. Twenty-two percent of the Michigan crop was sold by retail growers directly to consumers. Another 33 percent moved through wholesale channels to retail outlets. The largest part, 45 percent, was sold by growers to retail establishments.

Sales of retail florist outlets, on the other hand, totaled $30.3 million in 1949, more than four times the value of floriculture crops produced in Michigan. In addition to Michigan-produced flowers and plants, retail florist outlets sell a host of other goods and services, including flowers and plants shipped in from out of state, vases and gift articles, supplies and accessories, floral arrangements, and delivery services.

Retail florists supplied the largest part of the consumer market, selling 53 percent by value of all goods and services retailed in Michigan. Retail growers accounted for 25 percent of floriculture sales;

other outlets, such as department stores, fruit markets, and variety stores, handled 22 percent. No measure of the quantity of florist merchandise shipped in or out of the state is presently available.

INCREASING IMPORTANCE OF RETAIL FLORICULTURE TRADE

The number of retail growing and retail florist establishments in Michigan has shown a steady increase in the last decades (Table 1). Almost three times as many establishments were engaged in retail floriculture trade in 1948 as in 1929.

Sales trends have been more erratic. During the depression years sales by retail florists and retail growers declined sharply. By 1939 sales had not recovered to their pre-depression high. From 1939 to 1948 dollar sales increased almost four-fold.

To eliminate the effect of inflationary prices the dollar sales figure for 1948 has been converted to 1939 dollars in relation to the cost of living index. Assuming that retail florist prices increased at the same rate as the index of all retail prices, 1948 retail floriculture sales equaled $13,774 thousand in 1939 dollars. Thus, more than twice the pre-war volume of florist goods and services were retailed in 1948.

In the past 80 to 85 percent of all retail florist sales have consisted of flowers for funerals, weddings, hospital patients and holidays. If the potential market for flowers in everyday living can be developed, a favorable rate of growth may be maintained for years to come.

The rate of increase in retail floriculture trade has exceeded the rate of growth of Michigan's population and the increase in income payments to individuals (Table 2). From 1930 to 1950 Michigan had a 32 percent increase in population. Income payments to individuals increased by 154 percent, but sales by retail florists and retail growers in Michigan had risen by 214 percent.

TABLE 1—Retail establishments and sales of Michigan retail growers and florists, 1929-48

Year	Number of establishments	Sales in 1000 dollars
1929	376	7,535
1935	455	3,841
1939	703	6,335
1948	1,066	23,681

TABLE 2—Population, income payments to individuals, and retail floriculture sales, Michigan, 1929-49

	1929-30	1949-50	Percent increase, 1949 over 1929
Population, (thousand persons)	4,842	6,372	32
Income payments to individuals, (million dollars)	3,543	9,013	154
Retail floriculture sales by retail florists and retail growers, (thousand dollars)	7,535	23,681	214

OUTLETS ENGAGED IN RETAIL FLORICULTURE TRADE

Over half of Michigan's 1,223 establishments reporting retail floriculture sales were retail florists, not associated with flower growing (Table 3). Retail growers made up one-third of the total number, and, in addition, there were 157 other outlets engaged in retail floriculture trade. In Michigan there was one flower store for every 5,210 persons, whereas the United States average was one store for every 6,028 persons.

Slightly more than half of all sales were reported by retail florists, one-fourth by retail growers, and 22 percent by other outlets, such as department stores, variety stores, fruit markets. These other outlets sold a larger volume per establishment than either retail florists or retail growers.

Retail growers in Michigan had the smallest sales volume per outlet. However, their combined sales were 5.8 percent of all retail growers' sales in the United States. Michigan retail florists did not do so well in comparison with the United States total. Their sales were only 4.2 percent of all retail florist sales in the United States.

Michigan had 4.2 percent of the United States population but

TABLE 3—Michigan retail floriculture establishments and sales, 1948 and 1950

Outlets	Establishments reporting	Retail sales in 1,000 dollars	Percent of state total	Percent of U. S. total
Retail florists	661	15,987	53	4.2
Retail growers	405	7,694	25	5.8
Other outlets	157	6,600	22	4.8
All outlets	1,223	30,281	100	4.6

reported 4.6 percent of all income payments to individuals and 4.6 percent of all retail trade (Table 4). Retail floriculture sales, likewise 4.6 percent of the United States total, appeared to be closely related to income payments and to all retail trade. Retail sales of florist merchandise were about one-half of 1 percent of all retail trade in Michigan. This corresponds to the United States pattern. Retail florist sales equaled 0.5 percent of all retail trade in 25 of the 48 states and either 0.4 or 0.6 percent in 17 other states. Only in the Dakotas and in four southern states did retail florist sales amount to less than 0.4 percent of all retail trade.

TABLE 4—Michigan's share of U. S. population, dwelling units, income payments, retail trade, and florist trade, 1949-50

	United States	Michigan	Michigan as percent of United States total
Population, (thousand persons)	150,697	6,372	4.2
Dwelling units, (thousand units)	46,151	1,980	4.3
Income payments to individuals, (million dollars)	197,531	9,013	4.6
All retail trade, (million dollars)	130,521	5,950	4.6
Retail floriculture sales, (million dollars)	650	30	4.6

RETAIL FLORIST SALES BY SIZE OF CITY

For the United States as a whole there appears to be a definite relationship between the size of cities and the volume of retail florist sales (Table 5, Fig. 2). Half of the United States population resided in cities with a population of less than 10,000, but retail florists made only 16 percent of their sales in cities of this size. In these smaller places retail florist sales averaged less than $1 per capita, as against $4 or more in three groups of larger cities. It should be noted that the data pertain merely to retail florist sales and not to sales of retail growers and other outlets. However, even if retail grower sales were added to retail florist sales, the per capita sales in small cities would still be extremely low.

Per capita sales in cities over 100,000 were slightly higher than in cities with populations from 10,000 to 99,999 but the difference is not

TABLE 5—United States population and per capita sales of retail florists, by size of cities, 1949-50

	Cities of			
	Less than 10,000	10,000 to 99,999	100,000 to 499,999	500,000 and over
Population (thousand persons)	74,904	30,862	17,677	26,413
Retail florist sales (million dollars)	61	126	77	113
Per capita sales (dollars)	0.81	4.08	4.36	4.28

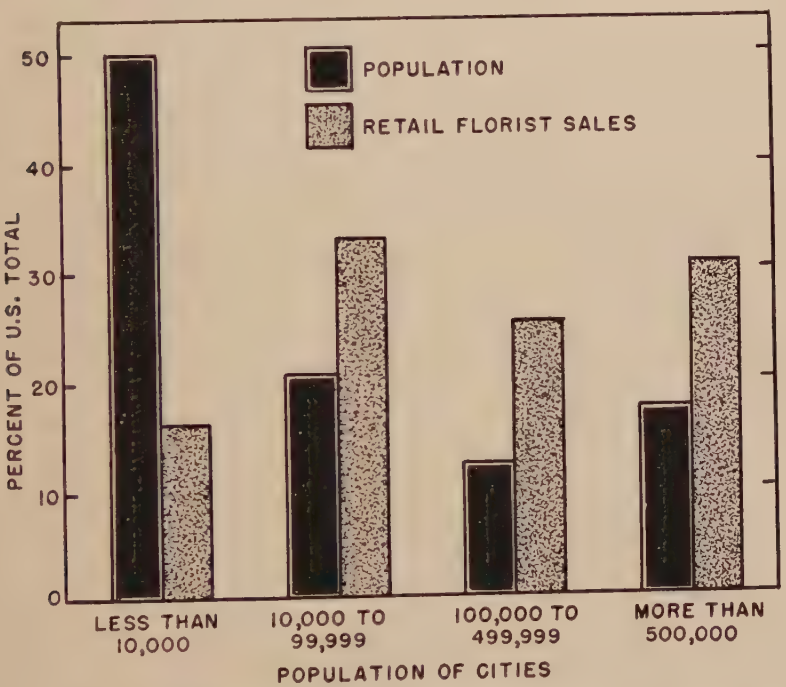

Fig. 2. Percent of United States population and retail florist sales by size of city.

especially significant. Larger cities appear to provide superior locations for the retail florist business. Although information was not available for Michigan alone, it is probable that a similar relationship could be found.

FLORIST TRADE IN METROPOLITAN MARKETS

Sixty-four percent of Michigan's population resided in seven metropolitan areas (Table 6). Seventy percent of the floriculture trade was concentrated around these metropolitan markets. Almost half of all retail florist sales were made to consumers in metropolitan Detroit.

Retail sales of floriculture goods and services in Michigan averaged $4.75 per capita, 10 percent above the average for the United States

TABLE 6—Population and retail floriculture sales. Standard metropolitan markets of Michigan, 1949-50

Market	Counties	Population		Retail floriculture sales	
		1,000 persons	Percent of state total	1,000 dollars	Percent of state total
Muskegon	Muskegon	121	1.9	574	1.9
Kalamazoo	Kalamazoo	126	2.0	1,148	3.8
Saginaw	Saginaw	153	2.4	787	2.6
Lansing	Ingham	172	2.7	1,278	4.2
Flint	Genesee	270	4.2	973	3.2
Grand Rapids	Kent	287	4.5	1,697	5.6
Detroit	Macomb, Oakland, Wayne	2,973	46.7	14,628	48.3
Combined	Metropolitan markets	4,102	64.4	21,085	69.6

TABLE 7—Retail floriculture sales per capita. Standard metropolitan markets of Michigan, 1949-50

Market	Per capita sales	
	Dollars	Percent of United States average
Kalamazoo	9.11	211
Lansing	7.41	172
Grand Rapids	5.91	137
Saginaw	5.15	119
Detroit	4.92	114
Muskegon	4.76	110
Flint	3.60	84
State of Michigan	4.75	110
United States	4.31	100

(Table 7). Per capita sales were exceptionally high in the Kalamazoo area; only three counties in the United States topped Kalamazoo in sales per capita.[2]

Lansing ranked second in sales per capita. Flint had the lowest florist sales per capita. It was the only metropolitan area in Michigan where per capita sales fell below the United States average.

SUMMARY

Total retail sales of floriculture goods and services in 1949 amounted to $30.3 million, over four times the wholesale value of Michigan flower production. In addition to Michigan-grown flowers and plants retail floriculture outlets sold floriculture products imported from other areas and a host of other goods and services, such as vases and gift items, accessories and supplies, floral arrangements, and delivery. Over half of the sales volume was handled by retail florists, not associated with flower growing, one quarter was sold by retail growers and the remaining 22 percent by non-florist outlets.

In general, persons residing in the larger cities are floriculture's best customers. Michigan's seven large metropolitan markets with 64 percent of the state's population had 70 percent of the retail floriculture trade. The Kalamazoo market, ranking first in retail floriculture sales per capita, was topped by only three counties in the United States. Per capita sales in the Flint market were lower than those in the other six metropolitan markets.

The number of retail florist establishments in Michigan has increased steadily since 1929. On the contrary, retail floriculture sales declined sharply during the depression. From 1939 to 1948 dollar sales have shown an almost four-fold increase. Future expansion appears to depend largely on development of the almost untapped market for flowers in everyday living.

[2]In 1951 Matson and Krone, Department of Horticulture, Michigan State College, found quarterly flower sales per capita of $2.51 in Kalamazoo, the highest sales in any of the cities studied. Flint ranked the lowest with quarterly per capita sales of $1.42. (Matson, Ed, and Krone, Paul R. (1951). Per capita sales vary in eight cities. Mich. Florist 247: 9.

A TWO-PRICE PLAN TO SELL MORE MILK[1]

By E. B. JONES and G. G. QUACKENBUSH
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THE DAIRY INDUSTRY has recently embarked upon rather ambitious programs of advertising, promotion, and education to increase sales of dairy products. A fairly long history of a declining demand for butter, an actual or potential substitution of vegetable fats for butterfat, and the lack of response of fluid cream sales to a rapid rise in population and consumer income have been of much concern to the industry. These developments give increasing emphasis to the importance of encouraging the consumption of fluid milk if the dairy industry is to maintain its present relative position in American agriculture.

This article describes a price plan and some merchandising techniques which conceivably would increase milk sales and expand consumption. The plan is designed to take advantage of the pricing structure for milk in some markets to give consumers an incentive to increase milk consumption. The plan, to the authors' knowledge, has never been put into operation in any market. Only the general framework of the plan is presented, from which modifications and adaptations could be made to fit particular market situations.

This article presents in fairly simplified and readable form the results of research based upon highly theoretical and complex economics. Thus, economic theory provided the tool for this research. To the agricultural economist economic theory provides a tool for analysis like chemistry and physics provide tools for analysis by the food technologist. An economist would bring economic theory to bear upon a problem in pricing milk much the same as a food technologist would bring chemistry and physics to bear upon a problem in food preservation. Both have done scientific research as they propose a solution to their problem, though neither may have actually made the test. In the writing of this article, the role of the concepts of

[1]This paper is primarily a summary of portions of a doctoral dissertation by E. B. Jones entitled: *Intra-Consumer Price Discrimination as a Means of Increasing Milk Consumption*, M.S.C., 1953.

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the indifference curve, cardinal and ordinal utility, marginal utility, marginal costs, partial equilibrium analysis, elasticity, substitution and complementarity, and others which were used in the analysis was deleted for the sake of wider readership, but at the risk of oversimplification. The basic concepts and some supporting data are contained in the thesis from which this article is derived, and are expected to be published later in a professional journal.

THE PLAN

The plan is a two-price plan, designed primarily for the sale of delivered milk during the months of flush production. In brief, here is the way the plan would operate.

Each household that purchased milk regularly from a route man would be sold its usual quantity of milk at the regular price. Then as an added incentive this same family would be offered the opportunity of purchasing additional milk at a reduced or discounted price. A mechanism similar to the base and surplus plan for producers would be used to allocate the quantities of milk sold to consumers at the regular and discounted price. For example, suppose a household had been taking three quarts of milk per delivery quite regularly during the fall and winter months. With the approach of the spring and summer months—the flush production months—the household would be advised that it had earned a base of three quarts per delivery.

Further, the household would now be eligible to purchase three quarts at the regular price of, say, 22 cents a quart and an additional quart at a reduced price of, say, 14 cents a quart. If the household is willing to purchase an additional quart at the lower price, it attains a higher level of satisfaction. If the sale can be made, the dairy industry stands to gain if the money received for this quart of milk is greater than the costs involved in selling it to the household.

JUSTIFICATION OF THE PLAN

The production of milk for direct consumption in most markets experiences wide seasonal variations, with considerably more milk being produced in the late spring and summer months than in the fall and winter months. Milk consumption, on the other hand, is fairly uniform from month to month. As a result of this divergence of production with consumption, large amounts of quality-inspected milk are diverted to lower class uses and lower price outlets as milk

for manufacturing in the spring and summer months. A two-price plan would attempt to move more of this inspected milk into channels of direct consumption in the months of flush production. The policy, which has been used in many markets for many years, of holding the retail price constant during seasonal increases in production has failed to offer consumers a price incentive to use this extra milk.

It is believed that a desirable two-price plan which would be attractive to producers, distributors, and consumers alike can be devised at least for home-delivered milk. It is possible that some variations of a two-price plan can be formulated for milk sold through stores. Some serious limitations and obstacles are present in the case of store milk, however, because of the inability to place certain restrictions and checks on consumers that would prevent the misuse of a two-price plan. However, the inability to devise a plan for store milk should not prevent the use of a two-price plan for delivered milk, if it can be accomplished without adverse effects on the market.

A two-price plan for selling milk would be designed to attempt to select from the market those families who showed some response to price variation. If these families can be segregated on the basis of response to price, then certain concessions can be made to them that would not fundamentally change the rest of the market. Families who might not increase milk consumption with a decrease in price for surplus milk would not receive any direct benefit from such programs. In other words, consumers would be in the very desirable situation that none would be worse off while some would be better off as a result of selling milk under a two-price plan.

NATURE AND SOURCE OF PRICE REDUCTION

One may ask how the industry can provide surplus milk at (say) 14 cents a quart when milk regularly sells at 22 cents per quart? The difference of 8 cents in this case may arise from two sources. First, in a great many markets there is a differential between Class 1 and manufactured milk prices of $2 and up to $3 per hundredweight. Assume for the moment that the differential is $2. This differential amounts to about 4 cents a quart plus a residual of over 15 cents a hundredweight. The residual could be used to defray part of the expense in administering the program. If the excess milk is diverted to manufacturing uses, the entire $2 is lost to producers. The dairy industry in general would receive some gain if less of the excess milk were diverted and more were sold for direct consumption. Consumers

could be offered a real incentive to increase consumption of milk just on the basis of this price differential in many markets.

The second source which may yield more or less than 4 cents a quart is plant and distribution costs figured on a variable or marginal cost basis. In these days of high costs for labor, plant equipment, and the like, it would not be uncommon for average milk plant costs to approximate or exceed 5 cents a quart. But once a business is in operation average costs have less influence on management decisions. Variable or marginal costs become important as a consideration to guide management decisions. In other words, the manager may ask: What would be my *additional* costs per quart if I were to increase my output 10 percent for 6 months? In many plants this cost would be exceedingly low, perhaps as low as 1 cent a quart. In fact, some plant operators claim that variable plant costs for a good operation can be less than 1 cent a quart. Suppose it were 2 cents, then 3 cents out of an average cost of 5 cents would remain. One cent of this residual might be retained as profit and used to cover the extra costs of administering the two-price plan. The additional 2 cents could be passed on to the consumer in the form of a reduced price for the surplus milk.

As a part of the marketing cost on a variable cost basis, delivery costs should likewise be considered. It would be quite common to find average costs for delivering milk to approximate 5 cents per quart. However, the cost of delivering some additional milk on the same route to established customers would be very low. In fact, studies show that the time required to deliver six quarts to a customer is only slightly greater than the time required to deliver one quart. Labor is by far the most important cost item in milk delivery. Assuming again that the variable cost of delivering milk is 2 cents, then 1 cent could be given to the milkman as an incentive for delivering an extra quart of surplus milk. The remaining 2 cents could be passed on to the consumer to reduce further the price of surplus milk.

The foregoing line of thought has illustrated how the 8-cent difference, or the 14-cent surplus milk could be made available to consumers by using a strictly business-type approach. It is conceivable that some markets could achieve even greater reductions on surplus milk while others would be limited by their price and cost situations.

It is admitted that a two-price system for selling surplus milk on a seasonal basis is not a simple or automatic merchandising tool. Neither is it a pricing policy that can readily be adopted by all markets. It involves some cooperation and joint effort on the part of segments

of the industry that have been reluctant to join hands in the past. Used indiscriminately, a two-price system could soon bring general chaos to the market. Used with caution and modified to fit particular situations where the general requirements of a two-price system can be met, it should mean additional sales of fluid milk at a profit. Each market would have to weigh its opportunities and then decide whether some variation of a two-price system could be made to fit its unique characteristics.

QUESTIONS AND ANSWERS

The following portion of this manuscript is devoted to questions and answers that are designed to explain and help clarify some of the problems that may arise in selling milk under a two-price plan.

Isn't a two-price plan a rather unusual merchandising policy in the dairy industry?

Yes, but the success and increasing use of this type of pricing in other industries suggests that it may have potentialities for the dairy industry. There are such features as quantity discounts, the Elwell plan, store differentials, and various kinds of rebates in some milk markets. Except for the Elwell plan, these systems amount essentially to non-seasonal, flat-price reductions. The Elwell plan treats delivery costs primarily on a marginal-cost basis, but does not offer the opportunity for increased sales that are proposed in this article. None of these plans is designed primarily as an attack on the seasonal problem of large surpluses in the flush production months.

The policy of retail price maintenance during the spring and summer months means that price is not used as a mechanism to increase sales at that time. The plan that is proposed can be considered a supplemental rather than an alternative technique to the usual pricing policies found in the market. A two-price plan is an alternative because a seasonal flat-price reduction is not profitable nor usually practiced by the dairy industry.

How will a two-price plan increase the sale of milk?

A two-price plan offers a price incentive for consumers to increase their consumption of milk. The consumer can consider this price incentive from an average or a marginal-cost basis. Either method produces favorable results toward encouraging increased milk consumption.

Suppose a family were purchasing two quarts of milk per delivery day at 22 cents a quart. Under a two-price plan, suppose it can purchase an additional quart of surplus milk at 14 cents a quart. This arrangement would mean that the three quarts of milk would cost the family a total of 58 cents, or an average of 19⅓ cents a quart. The family would be paying 2⅔ cents less per quart than the regular price in the market. It is common to reduce the price of milk by 1-cent graduations, which isn't nearly as great an incentive to increase consumption.

If the family considers the surplus milk on a marginal-cost basis it would mean that for an additional 14 cents it could have another quart of milk. This extra quart of milk at 14 cents could now compete on a marginal-cost basis with such items as the "cola" drinks, soda pop, lemonade, as a summertime beverage. The greatly reduced price on the surplus quart should encourage the substitution of this milk for other foods in the diet.

How would consumer bases be established?

Bases for families would be established with the aid of route books or other records which show the present and past consumption for the family. It is presumed that these records would reflect, in general, the probable future consumption of milk for the family. Where a family consistently purchased the same quantity of milk per delivery, the base would become the number of quarts taken per delivery, times the number of delivery days for the month.

Some families may vary their purchases considerably from one delivery to another, but their average purchases each month may be about the same. In this instance, the past monthly purchases would be the base. If monthly purchases vary slightly from one month to another, a base could be set by taking an average of the three or four months preceding the commencement of the two-price plan.

How much surplus milk would families be allotted?

The allotment of surplus milk could be set up as a ratio of milk purchased at the regular price. In other words, for every three quarts of milk normally purchased at the regular price, the family could purchase an additional quart of milk at the discounted price. For example, a family with a base of 60 quarts per month would be allowed to purchase 20 additional quarts of surplus milk while a family with a base of 24 quarts could be given a surplus allowance of 8 quarts.

Restrictions would have to be placed on the amount of surplus milk that families could receive in order to prevent re-selling to friends and neighbors, and to discourage the substituting of surplus milk for milk which would have been purchased at the regular price. Actual market circumstances and experience would have to dictate the allotments of surplus milk. If the undesirable effects of re-selling and substitution can be minimized, then a liberal policy should govern the sale of surplus milk so that milk consumption can be increased as much as possible.

How long should the plan operate each year?

The availability of surplus inspected milk at manufacturing milk prices would have to govern the duration of the two-price plan. This requirement is generally a seasonal opportunity, although some markets have surplus milk throughout most months of the year. It is possible that surplus milk in many markets at the present time may justify a two-price plan on a semi-permanent basis.

Habits pertaining to the consumption of milk are generally formed over a considerable period of time. The more entrenched these habits become, the more they are likely to persist as a permanent part of the individual's life. It would seem that a two-price plan should operate at least during the six months of highest production if surplus milk exists so that consumers would be encouraged to make those changes in their diets that involve longer-time adjustments.

How would people become acquainted with the program?

The methods used to publicize the program would depend upon the extent and nature of the program in the market. If the two-price plan was limited to certain families purchasing milk from deliverymen, it would be the obligation of the milkman to explain the program to his customers. He would be obliged to acquaint his families with the base and surplus allotments made for each family. Supplementary material such as handbills, letters from the dairy, and so forth, could be used to aid in this task.

More extensive promotional programs could be centered around such media as radio, newspapers, magazines, and television if the size of the market justified it.

What about store sales?

Purchases of milk from stores cannot be subjected to the same control and limitations that can be placed on delivered purchases in sell-

ing surplus milk. Multiple pricing may offer some limited possibilities. For example, with every three quarts of milk the consumer purchased at the regular price, a fourth quart could be purchased at a discounted price. There is, however, the possibility of substituting price-discounted milk for milk which would have been purchased at the regular price which is possible under this arrangement.

Could products other than fluid milk be used?

Yes—in fact, products such as chocolate milk and cream may be better suited for a two-price plan than fluid milk. Producer pay-plans in many markets classify milk going into chocolate milk and fluid cream as Class 1 sales. In these circumstances, the price differential between fluid and manufacturing milk would be available to be used as a price incentive for consumers to increase their purchases of these products.

The use of other products in lieu of fluid milk in promotional programs would tend to minimize the substitution or resale of surplus for regularly priced milk. Another advantage such products may have over bottled milk is the seasonal nature of the demand for these products. Chocolate milk is generally used as a cold beverage, which would make it ideally suited for promotional programs during the spring and summer months when seasonal increases in production occur.

Fluid cream could be promoted as a product to be used with fresh fruits and berries or in making frozen desserts and for similar purposes. Since cream would have considerably less substitutibility with fluid milk than would chocolate milk many opportunities could be exploited which would be impracticable under a two-price plan for either fluid milk or chocolate milk.

Could coupons or stamps be used in a two-price plan?

Yes—many persons associated with the dairy industry feel that price incentives are rather ineffective as a means of encouraging the consumption of milk. Rather than allow the discount on surplus milk in money, it is possible that the use of coupons or stamps which were redeemable in prizes or merchandise would be more effective in increasing milk consumption.

For example, suppose a coupon or stamp was worth 8 cents for each quart of surplus milk. If a family purchased only 15 quarts of surplus milk a month above their base allotment, it would receive

coupons for the month that would have a surrender value of $1.20. If a two-price plan using coupons and stamps continued for 6 months, the family would have coupons with a cash value of $7.20.

The price differential between regular and surplus milk would make possible very desirable and worthwhile prizes as a reward for collecting and saving coupons and stamps.

If it is assumed that the price of milk is 22 cents a quart and the coupons for surplus milk worth 8 cents a quart, then the family that increased its consumption 15 quarts for six months would spend an additional $19.80 for milk. In addition to receiving the 90 quarts of milk for the $19.80 expenditure, it would be possible for a family to earn merchandise valued at $7.20.

It is very possible that a well-planned promotion plan with coupons and stamps could best achieve the purpose of a two-price plan because of the demand creation effect of such a program as well as the simplicity and control that might be attained in administering it.

What would prevent a milkman from giving a family who purchased milk from a competitor a small base in order to get a new customer?

To prevent this undesirable activity it is suggested that only the milkman who delivered milk to the family during the base-building months (say the three or four months prior to the beginning of the program) could give a family a base and surplus allotment. This arrangement would mean that customers would have to continue taking milk from the same milkman in order to be able to take advantage of the two-price plan. Of course, if a family were dissatisfied with the product or service offered by one milkman, they would be free to change to another but in doing so they would lose the privilege of participating in a two-price plan for the year. The milkman would be charged the regular price for all milk that he received for delivery to new customers, so he would have no incentive to attempt to use price-discounted surplus milk to gain new customers.

What problems would producers face?

Two important problems must be solved for a two-price plan before producers would accept it. First, they must be assured that surplus milk sold to consumers at the discounted price would not adversely affect sales at the regular price, and second, dealers could not sell some of the surplus milk at the regular price and pay producers manufacturing milk prices for it.

The solution of the first problem would require that producers, dealers, and milkmen use a system of establishing base and surplus allotments for individual families that would prevent or minimize the substitution of surplus milk which would have been sold at the regular price. As already stated, this problem involves predicting the future consumption of milk at the regular price. Fluid milk consumption is stable enough for many families so that these predictions can be made fairly accurately. Restricting the quantities of milk that each family could purchase at the discounted price would also minimize undesirable substitution. It should be emphasized, however, that the allocations should be made so that the net effect of the program is favorable in terms of increasing fluid milk consumption rather than being concerned that no families "beat" the program.

The second problem involves accounting for the discounted milk by the dealer, which might require some auditing and checking to make certain that dealers do not misuse the surplus milk. The administrative problem of accounting for the surplus milk is similar to that of accounting for milk used in lower class uses. In other words the dealer would be charged Class 1 price for all the surplus milk he sold at a discounted price unless he could show by records which could be verified that the milk was part of the surplus program. It is possible that spot checks of route books would be sufficient in most instances.

Many other problems exist for the producers before a two-price plan would become a reality. However, it is assumed that producers would be willing to initiate those actions and make those concessions that are necessary to increase the consumption of milk as long as there was no conflict with their own self-interest.

What problems would the dealer face?

The problem of organizing and administering a two-price plan would largely fall to the dealers. The dealer would be responsible for maintaining accurate records of the surplus milk all the way from the producer to the consumer. At best, considerable administrative activity would be involved, but it is believed that it could be coordinated and delegated so that it would not become unduly burdensome in the operation of the program.

The nature of the competition and the cost structure of individual dealers may be a serious limitation to a two-price system. It may be that the advantages of a two-price system could not be equally dis-

tributed among the dealers so that cut-throat competition could be prevented. Some dealers may have very profitable alternative uses for their surplus milk and would thus hesitate to enter into a two-price plan. Other dealers may fear that a two-price plan for delivered milk would affect adversely their sales of store milk. Some dealers may not have sufficient control over their routemen to allow them to participate in a two-price plan.

Other dealer problems that might influence the operation of a two-price plan are institutional barriers as legal and anti-trust law restrictions, differences in the marginal cost structure for individual firms, the organizational structure of various companies, and historical development and sales practices found in the market.

It is readily seen that in some markets these limitations may be prohibitive obstacles to the inauguration and operation of a two-price plan. However, the search for ways and means to increase milk consumption and increase profit should be sufficient incentive for dealers to tackle these problems objectively in an effort to find a workable solution.

What problems would the milkman face?

The response of the customer to a two-price plan may be determined largely by the efforts of the milkman. If the consumer responds to a two-price plan the milkman should gain from the increased sales during the time the plan was in operation as well as any carry-over effect after the plan was discontinued for the year.

One of the major problems in the operation of the plan would be to get the milkman's cooperation in handling the surplus milk on a margional or additional cost basis. It may be a real problem to sell milkmen on the idea that they should receive a smaller margin for delivering a quart of surplus milk than for delivering regular milk. Still it is true that any profit to them above their expenses in handling surplus milk represents earnings that they would not have otherwise received.

Most dealer-milkman pay plans would have to be adjusted for a two-price plan in order to reflect the desired margin for surplus milk. This adjustment might cause considerable difficulty because of labor unions, unwillingness of some milkmen to participate, extra accounting, and administrative effort.

Accounting procedures would have to be established between dealers and milkmen to prevent the milkman from selling discounted

milk at the regular price and keeping the extra margin for himself. Many companies exercise little or no control over milkmen once they have charged specific wholesale prices for the various items that are loaded on the milkman's truck. A two-price plan would require that audits or checks be made to determine the exact outlets for the price-discounted milk to prevent the misuse of base and surplus allotments by the milkman.

A COMPARISON OF HAY, HAY-CROP SILAGE AND CORN SILAGE FOR EWES DURING GESTATION

By L. H. BLAKESLEE, H. A. HENNEMAN and R. H. NELSON[1]

DEPARTMENT OF ANIMAL HUSBANDRY

LIVESTOCK MEN have long been interested in the production of high quality roughages. Poor haying weather in early June has been a major limiting factor in any program to improve the quality of hay. The increased interest in hay-crop silage by sheepmen and other livestock producers has raised several questions concerning the value and methods of feeding.

Several tests conducted by the Ohio[2] and Kentucky[3] stations on the use of hay-crop silage revealed that pregnant ewes did well on it as a sole roughage. There still remains, however, several questions to be answered on the comparative value of hay-crop silage and other roughages for breeding ewes. The purpose of the two years of feeding work reported here was to answer some of these questions, of which the following are typical:

Will ewes that are fed hay-crop silage without grain during the gestation period drop strong lambs?

Will ewes fed high quality hay-crop silage produce enough milk for their lambs?

How does hay-crop silage compare with hay cured from the same crop, in respect to the production of lambs and the milking ability of the ewes?

How does hay-crop silage compare with a combination of hay and corn silage?

[1]Credit is due Dr. E. J. Benne for chemical analysis and Mr. Lee Bell, shepherd, and his helper, Mr. L. Gearhart, for care of the ewes.

[2]Bell, D. S. (1945). Farm Science and Practice. Ohio Agr. Expt. Sta. Bul. 659.

[3]Garrigus, W. P. (1941). Grass Silage. Ky. Agr. Ext. Circ. 361.

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DESCRIPTION AND MANAGEMENT OF EWES

The ewes fed in the 1951-2 trial were western Rambouillet-type fine wools. They had dropped one crop of lambs and were about 2½ years old or more when Suffolk rams were turned in on November 2, 1951. They remained on pasture until December 10 when they were transported to the experimental barn and fed hay-crop silage and corn silage. On December 21, the ewes were weighed, divided as equally as possible into five lots, as indicated in Table 3, and started on the five different rations.

In the 1952-53 trial, the experimental flock of 100 ewes was divided into two groups and bred to either a Suffolk ram or a Columbia ram. The ewes remained on pasture until December 18, when they were weighed individually, divided equally into experimental lots and fed baled hay and hay-crop silage. On December 23, the ewes were weighed and started on the different experimental rations. Eight ewes in each lot were bred to a Columbia ram and four were bred to a Suffolk ram. Nine ewes in each lot were of the fine-wool flock used in the 1951 trial. Three yearling ewes in each lot were westerns of Columbia medium-wool type.

FEEDS USED

The hay-crop silage fed during the first trial was made from an old seeding of alfalfa-brome. The forage was about one-third alfalfa and two-thirds brome. It was mowed, raked, chopped and then ensiled in a 10-by 30-foot silo with no preservative added. The hay for comparison was taken from another portion of the same field immediately

TABLE 1—Composition of roughages sampled Jan. 21, 1952

Sample designation	Percent						
	Water	Ash	Crude fiber	Ether extract	Protein	N-free extract	p-H
Corn silage	72.21	1.21	6.12	1.14	2.85	16.47	4.00
Hay-crop silage, from brome, timothy and alfalfa—mostly brome and timothy	74.77	2.33	8.57	1.34	3.94	9.05	4.96
Hay from brome, timothy, and alfalfa—mostly brome and timothy	11.73	5.53	31.60	1.66	10.38	39.10	.....

after the silage was harvested. It was mowed, raked and then baled as soon as dry. The corn silage was made from a Michigan hybrid, harvested with a field chopper and ensiled in a 14-by 40-foot silo after the corn was dented. Table 1 shows the laboratory analysis of the three roughages sampled Jan. 21, 1952.

The hay crop silage fed in the second trial was also made from an old stand which contained over 50 percent alfalfa and a mixture of timothy, smooth brome and other grasses. The hay was mowed and raked; then alternate windrows were harvested with a field chopper and ensiled with no preservative in a 10-by 30-foot silo. The remaining alternate windrows were left to dry and then baled. As previously, the corn silage was made from a good-yielding Michigan hybrid, harvested after the ears were dented. Table 2 shows the feed analysis of two samples of each roughage.

During the first two weeks of February 1953, small specks of white mold were found throughout the hay-crop silage. This was identified by Dr. C. J. Alexopoulos of the Botany and Plant Pathology Department as Specaria, a harmless white mold. In no instance did the ewes refuse the silage because of this mold.

A mixture of 50 percent trace mineral salt and 50 percent dicalcium phosphate was kept before each lot of ewes to insure sufficient minerals.

During the 1951-52 trial, all ewes were fed twice a day, morning and evening. In the 1952-53 test they were fed only once a day, usually during the afternoon.

TABLE 2—Composition of roughages, 1952-53

Sample designation	Percent					
	Water	Ash	Crude fiber	Ether extract	Protein	N-free extract
Sampled January 28, 1953						
Corn silage	69.58	1.11	7.17	.93	2.64	18.57
Alfalfa-brome silage	69.96	1.98	10.52	.98	4.75	11.81
Alfalfa-brome hay	9.91	4.78	33.89	1.60	13.06	36.76
Sampled April 1, 1953						
Corn silage	67.27	1.15	6.88	1.08	2.66	20.96
Alfalfa-brome silage	73.01	3.49	9.54	.93	3.51	9.52
Alfalfa-brome hay	11.88	5.89	35.76	.95	12.38	33.14

APPROXIMATE RATIONS FED 1952 AND 1953

		Pounds
Lot I	Hay	4
Lot II	Hay crop silage	10
Lot III	Hay	1½
	Corn silage	4
Lot IV	Hay crop silage	5
	Corn silage	4
Lot V	Hay	2
	Hay crop silage	5

All lots were fed approximately the above amounts up to lambing time with small variations. After lambing time the amount of roughage fed was increased according to the appetite of the ewes.

DISCUSSION OF RESULTS

The 1951-52 results (shown in Table 3) indicate that hay and hay-crop silage alone or together compared very favorably with their use when some corn silage is substituted. This is based on a comparison of Lots I, II and V with Lots III and IV. However, it must be noted that

TABLE 3—Average ewe weights, gains and daily ration with lamb birth weights and gains Dec. 21, 1951 to May 13, 1952

	Lot I	Lot II	Lot III	Lot IV	Lot V
	Hay	Hay-crop silage	Hay and corn silage	Hay-crop silage and corn silage	Hay-crop silage and hay
No. ewes started	13	13	13	13	13
Average initial wt. (lb.) Dec. 21, 1951	94.1	96	96	95.9	94.8
Average gain per ewe (lb.) Dec. 21-March 28, 1952	18	18.7	20	20	15
Average daily ration (lb.) Dec. 21-March 28, 1952					
Hay	3.7	.....	1.25	.....	1.61
Hay crop silage (lb.)	.....	10.07	.....	4.7	4.68
Corn silage (lb.)	.....	.....	4.29	4.03	.....
Average birth wt. of lambs (lb.)	11.5 *(12)	10.7 (13)	10.8 (12)	13.5 (10)	11.3 (12) 6.0 (2 twins)
Range in birth wt. (lb.)	8-14	9-15	9-12.5	10-13	6-13
Average daily gain per lamb					
Birth to April 21 (lb.)	0.44 (11)	0.36 (13)	0.51 (11)	0.50 (9)	0.39 (11)
April 21-May 13 on pasture (lb.)	0.76 (11)	0.81 (13)	0.72 (10)	0.77 (10)	0.76 (12)
Ewes not lambing	1	0	1 died	2, 1 died	0

*Number in parentheses ( ) indicates the number of lambs used in computing the average.

the ewes fed some corn silage made slightly greater gains, as did the lambs before going to pasture. The hay in this trial seemed to be a poor hay because it was largely a rather coarse brome grass with very little legume content. The ewes however, consumed it with very little waste. There was little difference in birth weight of lambs, with no apparent difference between lots in respect to strength or vigor at birth. All lambs were up and sucking in a very short time. No help was needed at birth except in the case of a very few large 12- to 15-pound lambs.

In comparing hay only (Lot I) with hay-crop silage only (Lot II), the ewe gains were practically the same. This was very favorable for Lot II, since on a dry matter basis, Lot II consumed about 2.5 pounds of hay-crop silage and Lot I 3.2 pounds of hay. However, in this test, the ewes did not milk as well when consuming silage, as in-

TABLE 4—Average ewe weights, gains and daily rations with lamb birth weights and gains Dec. 18, 1952 to May 26, 1953

	Lot I	Lot II	Lot III	Lot IV	Lot V
	Hay	Hay-crop silage	Hay and corn silage	Hay crop silage and corn silage	Hay and hay-crop silage
No. ewes started	12	12	12	12	12
Average initial weight (lb.) December 18, 1952	105.0	105.0	105.0	105.0	105.0
Average gain per ewe (lb.) Dec. 18-Mar. 24, 1953	15.5	5.6	18.0	19.9	15.1
Average daily ration (lb.) Dec. 23-Mar. 24, 1953					
Hay (lb.)	4.04	.....	1.49	.....	2.12
Hay crop silage (lb.)	.....	10.36	.....	5.10	5.10
Corn silage (lb.)	.....	.....	4.21	4.25	.....
Shelled corn, at lambing time (lb.)	0.62	0.69	.....	.....	0.62
Average birth wt. of lambs (lb.)	9.88*(13)	9.73 (16)	9.54 (14)	11.0 (14)	10.3 (14)
Range in birth weights (lb.)	7.5-11.5	6-14.5	8-11.5	9.25-13.5	5.5-13.5
Average daily gain per lamb, (lb.) Birth to April 23					
All	0.48 (11)	0.35 (11)	0.36 (12)	0.35 (12)	0.37 (12)
Singles	.50 (9)	.39 (9)	.42 (8)	.40 (4)	.44 (8)
Twins	.38 (2)	.29 (2)	.21 (4)	.26 (8)	.26 (4)
Average daily gain per lamb, May 11-26 (on pasture)					
All	0.66 (10)	0.74 (10)	0.60 (13)	0.61 (11)	0.63 (12)
Singles	.67 (8)	.80 (8)	.63 (9)	.63 (9)	.69 (8)
Twins	.60 (2)	.53 (2)	.51 (4)	.50 (2)	.50 (4)
Ewes not lambing	1	0	1 (died)	0	0

*Number in parentheses ( ) indicates lambs used in average.

dicated by the daily gain of lambs of 0.36 pound for those fed hay-crop silage and 0.44 pound for those fed hay. This difference had no effect on lamb health, but it would indicate the desirability of using grain before going to pasture. The greater gains, 0.81 pound per head daily, made by the lambs in the hay-crop silage lot when put on pasture, indicate the lambs' tendency and ability to compensate for early slow gains. After the ewes were put on pasture their milk flow increased.

The 1952-53 results (Table 4) were not favorable for hay crop silage, especially from the standpoint of ewe gain. All ewe gains were slightly lower than in 1951-52. The ewes on hay-crop silage, however, actually lost weight since the fleece weights averaged 6.8 pounds, and the total gain per ewe was only 5.6 pounds. This loss in weight of the ewes had no permanent effect on the lambs since the birth weights and daily gains were very similar to the other lots. It was necessary however, to add shelled corn on March 24 to the ration of the ewes fed hay-crop silage because they were very thin and their udders were not developing as they should. Corn was also added to Lots I and V on April 2. Lots I and V received 0.62 pound corn per head daily for 22 days, while Lot II received 0.69 pound for 32 days. Lamb gains show this amount of corn helped Lots II and V to equal the gains of Lots III and IV which were receiving one-half ration of corn silage. Lot I receiving the same amount of corn as Lot V averaged 0.48 pound per lamb daily gain in comparison with 0.35 pound in Lot II and 0.37 pound in Lot V. It must be pointed out that the Lot II ewes actually were fed an average of 10.36 pounds of hay crop silage daily up to March 24, but were fed 11 pounds daily beginning February 24 and 12 pounds daily per ewe from March 12 until they were turned to pasture.

These results indicate that the gains of pregnant ewes fed hay crop silage were more variable than were those of ewes fed comparable dry hay. The tables of feed analysis give little evidence of poor quality in the hay silage. The ewes consumed it well except when the ration was in excess of 10 pounds.

The hay-crop silage lot (II) and the corn silage, hay-crop silage lot (III) required three times as much bedding as did the other lots which received hay only or hay with one-half a ration of silage.

The loss of lambs in these trials, between birth and the time they went to pasture is not an index of the nutritive value of the rations. In Lot I the dam of a pair of twins had mastitis, while a third lamb

Fig. 1. On this page and the facing one are shown the five lots of western ewes with their young from either a Suffolk or a Columbia ram. The pictures were taken 18 days after the first lambs were dropped. The rations fed each lot are given below.

Top group: Lot 1. Brome-alfalfa hay, 4 pounds per ewe daily.

Middle group: Lot 2. Brome-alfalfa hay, 10 pounds per ewe daily.

Bottom group: Lot 3. Brome-alfalfa hay, 1½ pounds, plus corn silage, 4 pounds per ewe daily.

Fig. 1. (cont'd)

Top group: Lot 4. Brome-alfalfa hay silage, 5 pounds, plus corn silage, 4 pounds, per ewe daily.

Bottom group: Lot 5. Brome-alfalfa hay, 2 pounds, plus brome-alfalfa hay silage, 5 pounds, per ewe daily.

apparently doing well suddenly died. In Lot II, which included four pairs of twins, three lambs were removed from the experiment because their dam had milk for only one lamb. One lamb died of coccidia, one large lamb was dead when taken from the ewe, and a third lamb died of unknown causes. Three pair of twins were born in Lot III. One twin was removed for other experimental purposes. In Lot IV, one lamb died from accidental causes, the second lamb's dam died, and a third lamb's dam dried up after suffering from an everted uterus. In Lot V there was one loss of an accidental nature and another lamb was omitted in weighing.

These data indicate a greater need and desirability of adding corn or other supplements to a hay-crop silage ration if comparable gains are to be obtained. It must be recognized that better results could have been obtained if corn or other grains were added to all lots. How-

ever, the greatest need for supplementation with grain both years was in the hay-crop silage lot.

SUMMARY OF RESULTS

1. According to the results of these experiments, pregnant ewes can be fed good quality hay-crop silage as the only roughage when properly supplemented with calcium and phosphorus and still drop strong lambs.

2. Ewes in these tests preferred to eat the comparable dry hay and they and their lambs gained better than the ewes and their lambs on hay-crop silage.

3. On the basis of these two trials, it appears that ewes cannot always eat enough good quality hay-crop silage to provide the necessary nutrients and secure results comparable with hay.

4. Greater ewe and lamb gains were obtained when hay-crop silage was fed with corn silage or dry roughage than when fed alone.

5. To make ewes consume dry hay, hay-crop silage, corn silage or other roughages fed in combination, it was necessary to limit the amount of the more palatable roughage.

6. These tests indicate that, before and after lambing, hay-crop silage needs to be supplemented more with corn or other grains than the other roughages fed in these experiments if comparable results are to be expected.

7. Ewes being fed large quantities of silage require more bedding than when hay is fed.

MANAGEMENT RATIOS FOR ELEVATOR AND FARM SUPPLY ORGANIZATIONS, 1951-53

By H. E. LARZELERE
DEPARTMENT OF AGRICULTURAL ECONOMICS

AS THE MANAGEMENT of a business concern undertake to examine their past financial record and to plan their future operations, one of the most frequent questions is, "How do we stand today as compared with other similar firms?" A second frequent question is, "Are we proceeding on a sound basis, or are there some weaknesses that are creeping up on us?" The annual audit report of an association is often the only source of information on such questions. However, although very important, these reports are frequently so complicated in their usual form that it is difficult for the management of an organization to interpret and use the information as a basis for making important decisions.

Special Bulletin 380 of the Michigan Agricultural Experiment Station, "Ratios as Measuring Sticks for Elevator and Farm Supply Organizations," indicated some of the norms and the techniques that management could use in focusing the financial information of their association so that the foregoing questions could be answered more readily. The bulletin presented figures that were especially applicable to the years 1947-50. There is interest and frequent concern over the most recent financial operations of the elevator and farm supply organizations. This report brings up to date the norms set forth in the above-mentioned bulletin. They have been interested in knowing, first, whether this tendency existed in most concerns of this type or, second, whether their own organization had encountered some difficulties peculiar to its own situation.

An analysis of the ratios from the 1952-53 financial statements of 33 associations, compared with those of the previous year for the

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same organizations, indicates that most organizations apparently need to correct the following conditions:

1. Net Margin to Sales—a downward direction in the ratio values.
2. Salaries and Wages to Sales—an upward direction in ratio values.
3. Current Assets to Current Liabilities—a downward direction in ratio values.
4. Volume of Business—a downward direction in the dollar volume.

NET MARGIN TO SALES

Table 1 indicates that a reduction has occurred in the cushion between receipts and expenditures. Larger cushions are essential if organizations wish to achieve financial stability by building and maintaining adequate capital reserves and retiring indebtedness.

TABLE 1—Net margin to sales

Year	Lower limit of middle one-half of ratio values	Median	Upper limit of middle one-half of ratio values
1951-52	0.014	0.026	0.043
1952-53	.004	.016	.030

SALARIES AND WAGES TO SALES

Table 2 indicates a reduction in the economic efficiency of labor. This situation may have resulted from one or both of the following conditions:

1) A decrease in unit value of products handled without a proportionate decrease in labor costs.
2) A reduction in the physical efficiency of labor or a smaller number of physical units being handled per man.

The decrease in the value of this ratio is generally to be desired. It can be achieved by improving labor efficiency in general and, specifically, by using more labor saving procedures.

Correction of the salaries and wages to sales relationship will tend to improve the net margin situation.

TABLE 2—Salaries and wages to sales

Year	Lower limit of middle one-half of ratio values	Median	Upper limit of middle one-half of ratio values
1951-52	0.051	0.063	0.074
1952-53	.057	.066	.079

CURRENT ASSETS TO CURRENT LIABILITIES

The ratio of current assets to current liabilities cannot be interpreted accurately unless the two major parts of the current assets, the accounts receivable and inventory, are in good shape as indicated by the turnover ratios (see ratios number 6 and 7 on page 84). If the current assets are satisfactory, the downward movement of this ratio signifies a relative increase in current liabilities. This situation, in turn, may mean that bills owed by the organizations were not being paid as rapidly as before. The resulting loss of discounts that may occur should not be overlooked in efforts to improve the net margin and the general financial position of the organization.

TABLE 3—Current assets to current liabilities

Year	Lower limit of middle one-half of ratio values	Median	Upper limit of middle one-half of ratio values
1951-52	1.79	2.65	4.77
1952-53	1.45	2.56	4.08

VOLUME OF BUSINESS—TOTAL SALES

Table 4 indicates that most associations showed a downward movement in their dollar sales volume. Such a situation may be due entirely to price changes of commodities handled without a change in the physical volume handled. In any case, maintenance of at least the same dollar volume is important because many cost items are difficult to reduce. For example, in respect to the ratio of salaries and wages to sales, a decline in sales volume often is not accompanied by

TABLE 4—Volume of business—total sales

Year	Lower limit of middle one-half of sales values	Median	Upper limit of middle one-half of ratio values
1951-52	$286,975	$599,698	$883,259
1952-53	263,799	541,431	795,818

a comparable decrease in salaries and wages paid. If sales volume in dollars cannot be maintained it is imperative that the total salaries and wages be adjusted downward if net margins are to be maintained.

Concentration on the correction of some of these changes that prevailed in most of the associations may not be enough for every individual organization. The management can well afford to investigate to see whether additional corrective changes in policies or practices should be undertaken in case the ratio values of a particular organization are as follows:

1. If the net margin to sales ratio is *less than 0.004.*
2. If the operating expenses to sales ratio is *above 0.14.*
3. If the salaries and wages to sales ratio is *above 0.08.*
4. If the gross margin to sales ratio is *below 0.10* or *above 0.12.*
5. If the other income to sales ratio is *below 0.02* or *above 0.04.*
6. If the cost of goods sold to inventory ratio is *below 6.65.*
7. If the sales to accounts receivable ratio is *below 22.55.*
8. If the current assets to current liabilities ratio is *below 1.45* or *above 4.08.*
9. If the equities to total assets ratio is *below .54.*
10. If the sales to fixed assets ratio is *below 9.22* or *above 17.97.*
11. If the sales to total assets ratio is *below 3.03.*

There will be some exceptions where a ratio value will appear outside of the above-mentioned limits but still not reflect financial weakness. In any case the management can check these areas to see why their particular organization differs from many of the others.

In summary, pertinent problems arising in individual associations may suggest the need for corrective efforts in any one of the phases

reflected by the various ratios. The efforts that seem to be most needed by many of the organizations appear to be:

1) Maintain or increase dollar volume;
2) Adjust labor cost in line with declines in dollar volume; and
3) Keep current liabilities as low as possible, thereby taking advantage of discounts on purchases.

APPENDIX

*TABLE 5—Comparison of other ratio values**

Ratio	Year	Lower limit of middle one-half of ratio values	Median	Upper limit of middle one-half of ratio values
1. Sales/Expenses	1951-52	0.10	0.12	0.14
	1952-53	.11	.13	.14
2. Sales/Gross Margin	1951-52	.10	.12	.13
	1952-53	.10	.11	.12
3. Sales/Other Income	1951-52	.02	.03	.04
	1952-53	.02	.03	.04
4. Inventory/Cost of Goods Sold	1951-52	6.34	9.04	17.75
	1952-53	6.65	10.12	15.18
5. Accounts Receivable/Sales	1951-52	23.58	35.21	55.40
	1952-53	22.55	36.20	50.07
6. Total Assets/Equities	1951-52	.52	.69	.86
	1952-53	.54	.78	.85
7. Fixed Assets/Sales	1951-52	8.70	13.58	20.56
	1952-53	9.22	12.89	17.97
8. Total Assets/Sales	1951-52	3.02	3.46	4.90
	1952-53	3.03	3.39	4.75

*Includes data from annual financial statements in which the end of the fiscal year ranged from September 30 of one year to August 31 of the following year.

HOT WATER USAGE FOR DAIRY FARMS

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FOR many years the lack of sufficient hot water on dairy farms has concerned both the farmer and the water heater manufacturer. Little information is available on the selection of the proper sized water heater for the dairy, other than that the amount of hot water used is dependent upon the number of cows in the herd. Fore (1940) recommends from 7 to 10 gallons of hot water for each 10 cows when the herd is 20 cows or larger in size. No reference is made to the temperature of the water. According to the Michigan Milk Ordinance (Anon., 1942), "Suitable facilities for heating a sufficient amount of water shall be provided," but a standard has not been established for the amount and temperature of the water to be used. This article reports on a study conducted to determine the amount and the temperature of water used for sanitizing dairy equipment.

PURPOSE

During the summer of 1953 tests were conducted on 30 stanchion-type Michigan dairy farms, equipped with electric water heaters, to determine the amount and temperature of water used for the dairy farm enterprise. A second objective of the study was to establish criteria for determining the amount of water needed. A time-and-motion study of washing operations was also conducted, and the results obtained are included. A method is outlined to enable the farmer to select the proper-sized electric heater for his operation.

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Acknowledgment is given to J. M. Jensen, Associate Professor, Dairy, and B. F. Cargill, Instructor, Agricultural Engineering, for valuable assistance. Credit is given to Farm Service Advisors of Consumers Power Company, Herman Walt and Dennis Maguire, and to several farmers for their assistance in field studies.

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PROCEDURE

The study was conducted by observing the milking and utensil washing procedure and recording the amount and temperature of the water used for herds varying in size from 10 to 90 cows. A hot water meter and a thermometer were connected in the hot water line at the wash vat so that the temperature as well as the amount and rate of withdrawal could be determined. The data were obtained for a period of one day on each farm at the time of the evening and morning milkings. The average time for each milk house operation was determined (Table 1).

The milking operation required an average of 8.8 minutes per cow for each milking. After the equipment had been washed and placed upon the racks to dry, swab tests were conducted on the equipment with the exception of the milker inflations. The tests were made in accordance with the standard procedure as established by the American Public Health Association (1948) in its book, *Standard Methods for the Examination of Dairy Products.* This bacteriological study served as a guide in determining the quality of the washing operation.

TABLE 1—Average and range of time required for various washing operations

Operation	Average time (minutes)	Time range (minutes)
Disassemble milker	0.50	0.15 _ 1.25
Assemble milker	0.50	0.10 _ 0.95
Wash machine gaskets (two)	0.25	0.10 _ 0.50
Wash inflation cups (four)	0.50	0.20 _ 1.05
Wash 3 feet of milk hose	0.20	0.10 _ 0.60
Wash milker pail	0.80	0.20 _ 2.45
Rinse milker pail	0.20	0.05 _ 0.50
Wash milker head	0.60	0.10 _ 2.50
Rinse milker head	0.20	0.05 _ 0.45
Wash milker inflations (four)	0.90	0.20 _ 2.50
Rinse milker inflations (four)	0.25	0.05 _ 0.65
Disassemble strainer	0.40	0.20 _ 0.90
Assemble strainer	0.40	0.20 _ 0.60
Wash strainer	0.60	0.15 _ 1.45
Rinse strainer	0.20	0.10 _ 0.60
Wash 12-quart pail	0.30	0.20 _ 1.05
Rinse 12-quart pail	0.20	0.10 _ 0.30
Wash 14-quart pail	0.50	0.25 _ 1.20
Rinse 14-quart pail	0.20	0.05 _ 0.55
Wash 16-quart pail	0.60	0.30 _ 1.20
Rinse 16-quart pail	0.20	0.10 _ 0.30
Wash and rinse strip cup	0.40	0.30 _ 0.60

RESULTS

The amount of water used for washing the dairy utensils varied widely, with as much as 2 to 2½ times as much water being used for a given herd as compared with that used on another farm having a herd of comparable size. The wash water temperature did not vary widely, the mean being approximately 120°F. It was observed that a water temperature above 130°F. was harmful to body tissue, a temperature of 120°F. being comfortable for the operator.

The majority of the 30 heaters were located near the wash vats; 25 were within 5 feet, 3 from 5 to 10 feet, and 2 over 10 feet from the vats. Pressure-type heaters were used on 23 of the 30 farms, the water being piped under pressure to a double-sink wash vat. Pour-in type heaters were used on the remaining seven farms. Of the farms having pressure-type heaters, 22 of the 23 had a mixer faucet located at the wash vat.

The data collected on the 30 farms were analyzed statistically to determine the correlation between the amount of water used and the several factors involved. Correlation coefficients were run to determine the significance of the variables. The correlation coefficient between the number of cows in a given herd and the amount of water used for washing the utensils was 0.4092 and was significant at the 5-percent level. The correlation coefficient between the number of "units" washed and the amount of water used for washing the utensils was 0.4837 and was significant at the 1-percent level. Twenty six degrees of freedom were considered for determining the degree of significance. There was a significant relationship between the amount of water used and the size of the herd, but there was a closer relationship between the amount of water used and the "units" of equipment washed. The amount of water used for washing the utensils was based on the number of "units" washed. The "units" were determined by the relative surface area of the utensil according to the following schedule:

1 single milker unit	1.00 unit
1 strainer	0.25 unit
1 pail (16-14 qt.)	0.25 unit
1 pail (12-10 qt.)	0.20 unit
1 strip cup	0.05 unit

Washing the udders prior to the milking was practiced on 26 of the 30 farms. For this purpose, 0.17 gallon of wash solution at 110°F. was used for each cow at each milking. Jensen (1950) recommends

that, to aid in the control of disease, the milker teat cups be dipped in a germicidal rinse between cows during the milking operation. A germicidal rinse for teat cups was used on 12 of the 30 farms. This rinse required an average of 0.19 gallon of solution at 110°F. for each cow per milking. It should be noted that the quantities of solution mentioned are average figures and that the minimum quantity of udder wash and machine rinse was one pail of solution per milking.

Quantities of water for calf watering and miscellaneous use were not determined during this study. Stere (1948) recommends that ½ gallon of water at 155°F. be allowed for each calf per watering and that 2½ gallons of water at 155°F. be allowed for miscellaneous needs.

Short-tube milkers were used by 9 of the 30 dairymen. They used an average of 3.8 gallons of water at 120°F. for each milker washed; the remaining 21 farms, however, averaged only 2.8 gallons of water per milker washed. However, there was no statistical significance between the mean amount of water used for the short-tube milking machines and the water used for the long-tube milking machines.

The bacteriological studies indicated that there was a definite advantage in using a germicidal agent during the washing operation. This finding is in agreement with a study by Mallman (1944). Swab tests were made on the metal parts of the milking equipment. A synthetic detergent was employed on each farm, but only 40 percent of the farms studied used a germicidal agent in the wash solution. The American Public Health Association (1948) recommends that 100 colonies per 8 square inches of utensil surface be the maximum allowable tolerance in dairy manufacturing plants. The U. S. Public Health Service (1943), however, recommends that only counts of less than 100 colonies per 4 square inches be considered satisfactory for eating and drinking establishments. The contamination contributed by 100 bacteria colonies per square inch of area would amount to 4 colonies per milliliter of milk in a 14-quart pail. For purposes of comparison of data in this study, utensils having bacteria counts of 100 colonies per square inch of utensil surface were considered sanitary. It should be noted that swab tests were taken shortly after washing, a time when the counts were likely to be the highest. Swab tests made later would probably yield a lower count owing to the drying effect.

Without exception, a greater percentage of the utensils washed with a germicidal agent were sanitary as compared with the same type of utensil washed without a germicidal agent. In many instances

there were 67 to 75 percent of the colonies present when a germicidal agent had been used as compared with the number present when a germicidal agent had not been used (Table 2). These observations substantiate the belief that from a bacteriological point of view the use of a germicidal agent is beneficial for the dairy farm. The term, *percent sanitary,* gives a rapid indication of the percentage of the utensils tested that were considered sanitary.

*TABLE 2—Bacteriological data showing the relative effect of the use of a germicidal rinse on the cleanliness of the equipment**

Utensil	No germicidal agent (colonies)			Percent sanitary	Germicidal agent (colonies)			Percent sanitary
	0-100	100-500	500+		0-100	100-500	500+	
Milker pail A (side).....	6	4	6	37.5	16	1	0	94.2
Milker pail A (bottom side)..	6	7	2	40.0	12	1	0	92.5
Milker pail B (side).....	7	7	26	17.2	18	4	4	69.2
Milker pail B (bottom).....	17	5	18	42.5	16	2	7	64.0
Neck of strainer.	6	1	20	27.2	11	1	6	61.0
Side of strainer..	9	3	15	33.3	11	3	3	64.7
Milker head.....	21	12	8	51.3	20	2	4	72.9

Note: 100 colonies or less per square inch were considered to be sanitary.

There was little relationship between the hardness of the water and the cleanliness of the equipment after washing because a synthetic detergent was used at every farm (McCutchen, 1952).

The water hardness was determined by the Versenate method which consists of using a titration technique (Bersworth Chemical Co., 1952). The water hardness was expressed as parts per million of calcium carbonate.

The average water heater temperature on the farms studied was 155°F. and most well water was about 55°F. The common practice was to withdraw an amount of water at 155°F. from the heater and blend well water at 55°F. with it to produce the desired quantity and temperature of water for a given operation. A water temperature of 155° F. was used for determining the size of heater.

When one is selecting a water heater for the milk house, four main uses should be considered: namely, utensil wash, machine rinse and udder wash, calf watering, and miscellaneous use. A simple method for calculating heater size has been developed and is based upon water usage expressed in "units." The water used per machine rinse and udder wash, watering calves, and miscellaneous use was expressed as "units" of usage, on the same basis as the water used for washing the utensils as mentioned earlier in the paper. The standard used for determining the number of "units" required for a given dairy enterprise is as follows:

A. Utensil wash	
1 single unit milker	1.00 unit
1 strainer	0.25 unit
1 pail (16-14 qt.)	0.25 unit
1 pail (12-10 qt.)	0.20 unit
1 strip cup	0.05 unit
B. Udder wash and machine rinse (per cow)	0.10 unit
C. Calf watering (per calf per watering)	0.25 unit
D. Miscellaneous needs	1.15 unit

A method for determining the water heater size for a given dairy farm enterprise based upon the data collected in this study is as follows:

A. Determination of the required heater size:
   1. Determine the total number of "units" required, both before and after milking (above).
   2. Determine the required heater tank size by referring to Fig. 1.

B. Determine the required heater element size according to N.E.M.A. standards. Consult your local power supplier for off-peak heater operations. If the heater selected in Part A is less than 30 gallons, the minimum element size must be large enough to bring the heater back to temperature between the milking operations.

An example is presented to demonstrate the method outlined above.

Example 1:

Conditions:

30 cows in herd, 3 single unit machines, 2 strainers, two 16-quart pails, four 10-quart pails, one strip cup and 5 calves.

A. Determination of the required heater size:

1. Determine the total number of "units" required both before and after milking (see page 91).

3 single unit milkers	3.00 units
2 strainers	0.50 units
Two 16-quart pails	0.50 units
Four 10-quart pails	0.80 units
1 strip cup	0.05 units
Calf watering	1.25 units
Miscellaneous needs	1.15 units
Udder wash and machine rinse	3.00 units
Total water usage in units	10.25 units

2. From Fig. 1 it can be seen that a heater of the 30-gallon size is required.

B. Determination of the required heater element size. According to N.E.M.A., the lower element should be 600 watts and the upper element should be 900 watts. Consult your local power supplier for allowable element size for "off-peak" heater operation.

When a heater selected for any given herd is 30 gallons or larger, it may be attached to an "off-peak" mechanism to control the operation of the lower element. When "off-peak" heaters are selected, the heater must be large enough to provide for hot water usage before and after milking. In general, "off-peak" heaters must conform to N.E.M.A. standards (National Electrical Manufacturers Association) to entitle the user to "off-peak" rates for water heating. In Michigan, heaters having tanks with a capacity of less than 30 gallons are not considered as "off-peak" heaters, and the heating element sizes may not conform to N. E. M. A. standards. N. E. M. A. and Pfingsten (1949) recommend that the lower element size be limited to 20 watts per gallon of tank capacity and that the upper element size be limited to 30 watts per gallon of tank capacity. In any event, it would be

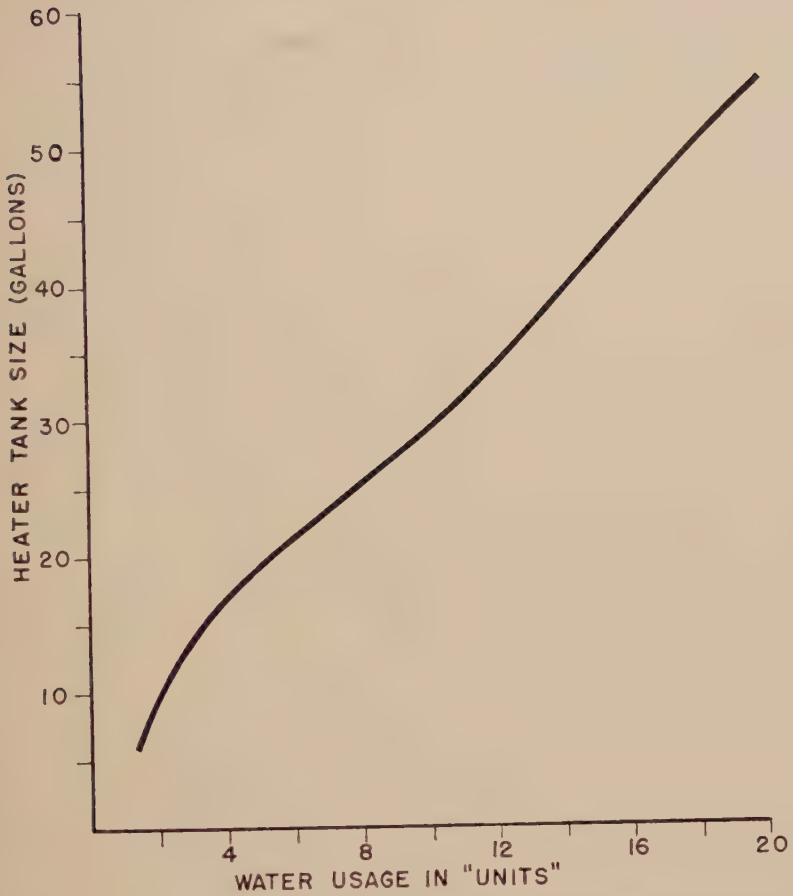

Fig. 1. Heater tank size required relative to water usage in units.

well to consult your power supplier regarding "off-peak" water heater operations.

CONCLUSIONS

1. The amount of water used for washing the dairy utensils in the milk house was dependent upon the amount of equipment to be washed.

2. Each utensil unit washed required an average of 2.7 gallons of water at 155°F. per washing. This water was later blended with 55°F. well water for the actual washing operation.

3. The hardness of the water supply had no noticeable effect upon the quality of the washing operation as every farmer visited was using an adequate amount of synthetic detergent.

4. From this study there appears to be a definite trend toward the larger "off-peak" water heaters for the milk house.

5. A majority of the dairy farms surveyed used a germicidal agent in the wash water. Such an agent is beneficial in the washing operation.

LITERATURE CITED

American Public Health Association (1948). *Standard Methods for the Examination of Dairy Products*, 9th ed., American Public Health Association, New York, p. 52.

Bersworth Chemical Company (1952). The Versenes for Exacting Chemical Control of Cations in Solution. Tech. Bul. 2, Bersworth Chemical Company, Framingham, Mass., Sec. 3, pp. 5-7.

Cargill, Burton F. J. (1952). Methods engineering analysis of loose housing dairy barns. Thesis for degree of M.S., Michigan State College, East Lansing. (Unpublished).

Fore, J. M. (1940). Water heaters for the small dairy. Electricity on the Farm. 13: 13-16.

Jensen, J. M. (1950). Practical sanitation in caring for milking machines. Mich. Agr. Expt. Sta., Cir. Bul. 218, pp. 24-25.

Mallmann, W. L. (1944). Notes on the sanitation of dairy equipment, Mich. Agr. Expt. Sta. Quart. Bul. 27: 112.

McCutchen, J. W. (1952). Synthetic detergents up to date. Soap and Sanitary Chemicals, 28: 49.

Anonymous (1942). Milk Ordinance Committee of the Michigan Allied Dairy Association. Michigan Milk Ordinance, March 18, 1942.

Pfingsten, A. A. (1949). Off-Peak water heaters and radiators in milk houses. Farm Electricity 3: 36.

Stere, J. B. (1948). How big a dairy water heater? Electricity on the Farm, 21: 8-12.

U. S. Public Health Service (1943) Ordinance and Code Regulating Eating and Drinking Establishments. Public Health Service 37, p. 34.

THE GRAZING OF DORMANT WINTER WHEAT BY WILD GEESE

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Each fall the common wild goose *(Branta canadensis)* migrates across Michigan, and some farmers benefit from renting goose hunting rights or by permitting relatives and friends to hunt with them. Some flocks winter in southern Michigan; and, in spring, large concentrations of wild geese occur at many places. In March and April, these birds often feed on winter wheat. So-called damage is reported; yet no prior study seems to have been made of the effect this goose feeding may have on wheat yields. The present study was prompted by the writer's observations of wild geese in southwestern Michigan, on and near the Kellogg Station of Michigan State College.[2]

In 1951, with help from the Departments of Farm Crops and Soil Science, two field experiments were completed in southwest Barry County. A controlled test of grazing, using captive geese, was also made on the College Farm at East Lansing.

In January 1951, 250 questionnaires were sent to farmer residents in northeast Kalamazoo County and southwest Barry County to locate examples of goose grazing on wheat. The names were selected at random from lists supplied by the county agricultural agents. Most of the farmers polled lived within 10 miles of the Gull Lake-Crooked Lake Canada goose concentration. (In fall the birds use Gull and Wintergreen lakes, both sanctuary areas; but in spring they virtually desert these in favor of other lakes and ponds.)

A total of 120, or almost 50 percent, of the questionnaires were returned. More than a third of the farmers (44) reported little goose

[1]The author was helped in this study by many persons. Especial thanks are due H. L. Hobbs and Silas Doster on whose farms the field experiments were made. County agricultural agents A. J. Steeby and V. F. Hinz, of Barry and Kalamazoo Counties, provided many farmer contacts. Professors E. P. Whiteside and I. F. Schneider, identified soil samples; and Prof. H. M. Brown threshed and weighed the grain and evaluated the test yields. Many helpful suggestions were received from these people and from Prof. Don W. Hayne of the Department of Zoology and Prof. Peter I. Tack, head of the Department of Fisheries and Wildlife.

[2]Located 12 miles northwest of Battle Creek, the Kellogg Station includes the Bird Sanctuary which the author managed for the College from 1931 to 1948.

ARTICLE 37-11

Fig. 1. In southwestern Michigan, flocks of wild geese "loaf" and feed on many fields of winter wheat, especially in early spring.

grazing and little or no loss; 24 reported damage to unharvested corn; and about one out of four either complained of damage to winter wheat by goose grazing or feared such losses. A similar inquiry made in 1953 indicated no change of farmer opinion or goose behavior.

The hunting pressure is so steady during October and November that wild geese feed repeatedly on only a few farms; but after the close of shooting, the wintering geese travel from the Kalamazoo River to farm fields, where snows are not too deep, to feed in corn or wheat stubble and on the winter wheat. Return migration is under way by early March. One large concentration builds up each year at Crooked Lake, the vicinity chosen for intensive study and experiments in 1951.

Between January and late April, the writer made 15 trips to this goose area to visit fields used by the geese and to observe their feeding habits. Of 74 observed flights of geese to farm fields, 26 flights were

to winter wheat, 23 to picked cornfields, 5 to standing corn, and 20 were to meadows, pastures or marshes. No apparent increase in the use of winter wheat fields was noticed as spring plowing deprived the birds of the cornfields.

NATURAL GRAZING STUDIES IN BARRY COUNTY

An attempt to measure wheat yield differences due to goose grazing —if such occurred—was made on two farms in Prairieville Township of Barry County, about 2 miles south of the village of Prairieville. Both farms border Crooked Lake and have a long history of use by geese. The area is characterized by plateaus and slopes, many potholes and swales, with some good soils but with varying amounts of sands and gravels.

LOCATION A

Hobbs Farm: This was a rolling 13-acre wheat field, bordered on two sides by a pond and a bayou of Cooked Lake. Permission was secured to put up scare devices and to take yield samples. As early as March 2, a flock of 30 geese fed on this field, but during the next few weeks larger flocks were present on many occasions. By March 19 fully half of the field had been grazed. Winter kill in the wheat was not evident, but some heaving due to frost had occurred. Trampling was in evidence at the shoreline.

Two tent-like scare devices were put up on an ungrazed knoll on March 20 to save certain plots for samples of ungrazed wheat. Also two chicken-wire pens were built to preserve other check plots. On April 21, after the geese had left for the North, six plots were staked for taking sample yields at harvest time. (These included three grazed and three ungrazed plots.) On July 13, grain samples were harvested, consisting of all the grain from a 36 square-foot sample from each plot. Table 1 summarizes conditions and yields.

LOCATION B

Silas Doster Farm: This was an 18-acre field of winter wheat, where wild geese had fed the previous fall and were likely to return in spring. The field borders Cooked Lake, the usual loafing place for fully 2,000 geese each spring.

Weekly field observations enabled the writer to follow the progress of goose feeding and to select sites on which wheat yields might be

TABLE 1—Summary of experiment A, Hobbs Farm, on a 13-acre winter wheat field in Barry County used by wild geese, March-April 1951

Station number	Degree grazed (spring only)	Soil type	Height of wheat on May 25, in inches	Yield on July 13, in bushels per acre
1.....	Ungrazed.....	Boyer light sandy loam..	16	21.2
2.....	Ungrazed.....	Brady loam.....	18 to 19	34.5
3.....	Much grazed.....	Celina loam.....	16	29.1
4.....	Much grazed.....	Conover silt loam.....	18	31.6
5.....	Much grazed.....	Bellefontaine or Boyer...	18	25
6.....	Ungrazed.....	Bellefontaine or Boyer...	19	26

compared. Heavy grazing began late in February, and by March 10 the geese had fed well up the slope. On that date, six plots were selected and marked as representing sites both favorable and unfavorable for growing wheat and including grazed and ungrazed samples.

Plots 8 and 12 were given the protection of three scare devices, half-open tents or blinds. These apparently flimsy structures were actually well braced, but the ends were permitted to flap in the winds. Old carpets, camouflage net, and bags were used for covering. Apparently the geese did not like these "scares," for as they grazed up the slope they left ungrazed a 5-rod strip next to the devices. However, winds eventually flattened one structure, and the geese then completely grazed plot 12; thus this check sample was lost.

During March the shore site, plot 9, was very heavily trampled; but grazing in April was light, possibly limited to some extent by the scare devices. The geese moved away in late April, but not until about one-third of the field had been grazed.

During the spring the author failed to find evidence of digging or pulling of wheat, although this is often charged to the geese. Observations indicated that all feeding was the usual clipping or grazing, leaving the roots undisturbed. Winter kill was not evident; but on a few of the areas a few plants seemed to have been heaved by the frost.

On July 13 the yield samples (36 square feet each) were collected as at location A. The summary of conditions and yields is given in Table 2.

DISCUSSION OF NATURAL GRAZING EXPERIMENTS

Table 1 shows the results of experiment A. Yields were definitely better on favorable sites, with seemingly little difference attributable to the geese. Grazed plot 5 yielded only 1 bushel less than did ungrazed plot 6. These two plots were selected for similarity; the degree of grazing was the only recognizable difference and both represented eroded slopes with good soil. (The owner reported the field averaged nearly 30 bushels per acre.)

Table 2 shows that at location B the highest wheat yields came from the better soils on the more favorable slopes. Lowest yields were from the severely eroded sites—plots 7 and 11, which yielded

TABLE 2—Summary of experiment B, Doster Farm, on an 18-acre winter wheat field in Barry County used by wild geese, March-April 1951

Station number	Degree and time of grazing	Soil type	Erosion*	Height of wheat on May 25, in inches	Yield on July 13, in bushels per acre
7.....	Slight, fall and spring.	Miami loam.....	2	14	13.3
8.....	Ungrazed (check)....	Miami loam.....	1	23	25.0
9.....	Much, fall and spring.	Washtenaw sandy loam..	0	"short"	15.6
10.....	Much, spring only....	Miami loam.....	1	20	25.0
11.....	Much, spring only....	Bellefontaine.....	3	12	9.8
12.....	Much, spring only....	Bellefontaine or Boyer...	3	21	20.8

*Erosion ratings (1 to 5) indicate slightly to very severely eroded.

at the rates of 13.3 and 9.8 bushels per acre, respectively. Plot 9, having better soil but being a wet site, ran only 15.6 bushels; and plot 10, on good soil, yielded 25 bushels although it had been grazed. This equalled the yield from ungrazed plot 8. On May 25, the wheat on grazed plot 10 was 20 inches tall, and only 3 inches shorter than the ungrazed plants at plot 8, on good soil. (Mr. Doster reported that the average yield was only 22 bushels and that another field, not used by geese, also failed to produce as well as had been expected.)

It is believed that both field experiments involved samples of normal goose grazing such as commonly takes place on many farms of southwestern Michigan. The experimental results seem to support the prevalent farmer opinion that relatively little loss of wheat can be demonstrated as being due to geese grazing on dormant wheat.

(This study did not include the grazing of sprouting wheat.) Statistical evaluation of the plot yields failed to show that the geese had affected wheat yields, according to Prof. H. M. Brown, of the Farm Crops Department, who threshed and weighed the samples, and who also analyzed the findings.

General observations at grazed fields of the study area showed that, as a rule, the heaviest grazing occurred close to water areas, at and near goose "loafing" places. Winter wheat does not seem to be a preferred food, since of 74 feeding flights observed, only one-third were to fields of winter wheat. (Almost every farm in the area grows some wheat and corn.)

In the 1951 opinion poll, a cross-section of attitudes towards geese on croplands was obtained. This is well illustrated by the following comments:

> 1—"I usually pasture my wheat in fall with cows so cannot determine any loss from the birds."
>
> 2—"I am supposed to be indignant about the great damage—according to local farmers—but frankly, the only great harm is the noise and hunter irritation."
>
> 3—"They about cleaned 5 acres of wheat."
>
> 4—"The geese did graze the wheat here heavy in the spring of 1950 but it is hard to say the exact extent of damage. I did have some poor spots in the wheat but they were the low spots and I thought that most of the damage was winter kill."
>
> 5—"My fields of wheat, corn and alfalfa have been ruined for the past years by thousands of those geese."
>
> 6—"Any wheat I have had pastured by wild geese yielded as heavy or more than the wheat that they left alone. Why, I can't say. I don't know of anyone who can say the geese have hurt him, even in this neighborhood, if they told all the truth."
>
> 7—"As long as they don't do any more damage to my wheat in the future than they have in the past, the geese and I will get along O.K."

The follow-up questionnaire sent out in August 1953, (three harvests later) showed no shift in opinion one way or the other. Of the 100 forms sent out, 48 replies were received. Only 9 answers indicated a belief in damage by the geese; and 34 indicated no damage.

EXPERIMENTAL GRAZING BY CAPTIVE GEESE

Difficulties encountered in the field tests suggested the use of captive geese in a movable pen for an intensive study of grazing as it

affected yields. A nearly level wheat field was made available by the Farm Crops Department near East Lansing. This field was planted late, and the wheat had grown, on the average, about 6 inches before winter.

The Game Division of the Michigan Department of Conservation loaned three Canada Geese. These were confined in a circular pen made of 27 feet of 4-foot snow fencing, covered with heavy netting fastened down by hog rings. This easily movable pen was braced against flopping geese and strong winds by being tied to two steel rods pushed into the ground on opposite sides. A pail of water was provided within reach of the geese; but artificial feeding was limited to a few handfuls of grain during the first three days while the birds were learning to graze. The geese were fairly tame and were switched from whole corn to the wheat leaves as their sole diet.

In a 9-day period (April 11 to 20) the three geese were progressively grazed on 12 plots. At the end of the experiment, six check plots were staked out as shown in Fig. 2, one in line with the grazed

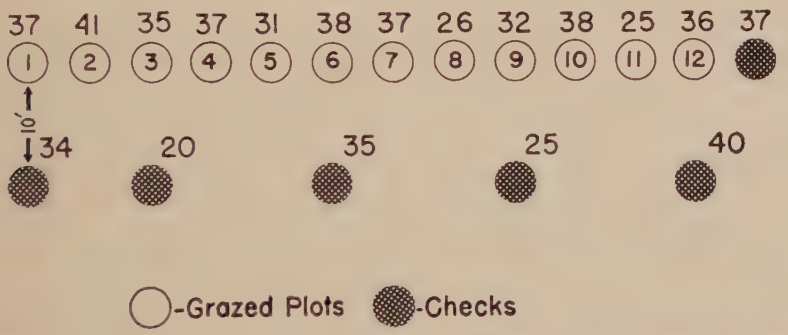

Fig. 2. Arrangement of grazed and check plots (about 9 feet in diameter) in experimental grazing of dormant winter wheat by captive Canada Geese, April 11 to 20, 1951, on the College Farm, near East Lansing. Yields in bushels per acre are shown by figures outside the circles. The grazed plots were contiguous.

plots and five in a parallel row 10 feet away. Table 3 summarizes this experiment.

Weather conditions greatly favored this test since low temperatures kept the wheat dormant, and rain and snow gave a good test of possible damage by puddling or the geese trampling the soft ground. Warm weather arrived on April 20; and rapid growth soon indicated

TABLE 3—Summary of controlled grazing on 12 plots, April 11-20, 1951 by three captive wild geese, on the College Farm at East Lansing. Pen was moved so that plots 1 to 12 were grazed consecutively (see Figs. 2 and 3).

Plot number	Starting time	Total hours	Daylight hours	Extent grazed	Rate of yield, bushels per acre
1.....	Apr. 11, 12:30 p.m...	19.5	9.5	light	37.0
2.....	Apr. 12, 8:00 a.m...	4.5	4.5	light	41.5
3.....	Apr. 12, 12:30 p.m...	4.0	4.0	medium	35.7
4.....	Apr. 12, 4:30 p.m ...	16.5	6.5	much	37.7
5.....	Apr. 15, 11:00 a.m...	6.0	6.0	much	31.4
6.....	Apr. 15, 5:00 p.m...	24.0	14.0	light	38.1
7.....	Apr. 16, 5:00 p.m...	15.0	5.0	medium	37.8
8.....	Apr. 17, 8:00 a.m...	10.3	10.3	much	26.0
9.....	Apr. 17, 6:20 p.m...	18.0	8.0	much	32.7
10.....	Apr. 18, 12:20 p.m...	20.5	10.5	heaviest	38.7
11.....	Apr. 19, 8:30 a.m...	8.5	8.5	much	25.0
12.....	Apr. 19, 5:00 p.m...	17.5	7.5	very much	35.9

fair recovery. (Fig. 3, c.) The yield samples were taken on July 13. Each included all the grain within a 4-foot square (16 square feet) at the center of each plot.

The grazed plots yielded at the rate of from 25 to 41 bushels, while six ungrazed check plots varied from 20 to 40 bushels. In April water had stood on grazed plots 5 and 11, which yielded lower than all but one other grazed plot. Unfortunately, no record of moisture conditions is available for the check plot which produced at the rate of only 20 bushels.

It will be noticed that some of the highest yields were from areas on which geese were kept the longest time—plots 1, 4, 6, 7, 10 and 12. Theoretically, trampling should have been heavier and, if destructive, losses greater. It is often claimed that goose grazing causes wheat to stool out and also that goose droppings are good fertilizer. If these claims are true, then there may be compensating influences.

CONCLUSIONS AND SUMMARY

Flocks of wild Canada geese graze considerably each spring on fields of winter wheat in southwestern Michigan. Local opinion differs as to the effect of such grazing on wheat yields. Field observations in southwestern Michigan indicate that flocks of geese regularly clip and graze but seldom pull the dormant wheat plants.

Fig. 3. The appearance of an ungrazed check plot and that of a heavily grazed plot (No. 10) on the College Farm near East Lansing.

(Top) The ungrazed check plot on April 20.

(Middle) The grazed plot also on April 20.

(Bottom) The grazed plot on April 27, after one week of growing weather, showing recovery.

Two field experiments were conducted in Barry County under natural conditions, and one experiment was conducted on the College Farm at East Lansing, using captive geese.

Yields varied considerably as sites varied, and standing water seemed to cause heavier losses than did goose grazing. Close-cropped, trampled wheat made rapid recovery after growth started on April 20. The experiments did not reveal any reduction in wheat yields attributable to goose grazing on dormant plants.

The determination of how much wild geese may affect winter wheat is handicapped by such other factors as poor drainage, heaving by frost, and the uneven topography and varied soils of most wheat fields.

Many wheat fields in southwestern Michigan are on sloping or rolling land where grazing by geese or by cattle may increase soil erosion hazards. Tent-like scare devices may at times keep wild geese off such fields.

The present study did not deal with the effect goose grazing *may have* on *newly-sprouted* grain. Such a study should be made.

FUNGICIDE TREATMENT OF TABLE BEET AND SPINACH SEEDS FOR THE PREVENTION OF DAMPING-OFF[1]

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THE PURPOSE of the work reported in this article was to evaluate the status of chemical treatments of vegetable seeds for the control of damping-off. The report covers part of the work on a continuing program of vegetable seed treatment testing begun in 1948. Because the literature on seed treatment is voluminous, only articles pertinent to the discussion are cited, Leukel (1948), Taylor and Rupert (1946) and Walker (1948) treat the subject extensively. Although some results differ from those previously reported, they are very similar in many respects, and some differences are to be expected when dealing with a biological complex of seed, soil, fungicide, pathogen, and environment. Confirmation of the work of others is stressed because it is an indication of broad application; the criterion of any plant protection chemical must be its practical effectiveness under many conditions.

Organic compounds have nearly replaced the inorganic materials used in the past when copper and zinc compounds, usually oxides, were preferred (Cook, 1935 and 1937; Pirone, 1933). These still are useful, particularly for spinach. The germination of seeds of beets, eggplant, pepper and spinach is stimulated more by the presence of free copper than that of certain other seeds (Foster, 1947) whose germination is delayed or inhibited by the action of copper. The organic mercury compounds, because they were injurious or ineffective if improperly used (Brett and Dillon-Weston, 1931; Cook, 1937), were never received quite as favorably as have been the later, non-metallic organic compounds. In certain cases, however, the organic mercury materials were among the best, as shown by Gould (1943) and Leach (1940). Leach found that red copper oxide was satisfactory for control of damping-off caused by *Pythium ultimum*, but the organic mercuries were better where *Rhizoctonia solani* was the chief pathogen.

[1]Contribution 54-3, Department of Botany and Plant Pathology.

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Beets and spinach are extremely sensitive to damping-off (Cook and Callenbach, 1935; Pirone *et al.*, 1933; Taylor and Rupert, 1946). Because of this and, also, the expense of re-seeding, much work has been done on seed protection of such crops. A seed treatment material should not only be effective but also should be safe to use and suitable for many crops and conditions of growth. Many new materials appear on the market each year. These must be evaluated experimentally in Michigan in comparison with standard materials because their applicability under Michigan conditions is of practical significance to the growers. The results reported here form the basis for the present recommendations of use.

MATERIALS AND METHODS

The fungicide materials used in the experiments are given in Table 1. Some of them were used on only one occasion, while others were used repeatedly. A few of the best were used consistently for comparison of degree of effectiveness.

The methods of application of a fungicide to the seed varied. In general, dust applications were made as follows: 1) The weight of an average seed sample was determined. 2) The amount of chemical required to give a certain number of ounces per hundred pounds of seed was calculated. 3) Dust and seed were mixed thoroughly in a small covered container for 10 or 15 seconds. 4) As for small seeds, such as those of beets and spinach, all replications were treated as one bulk lot. Individual row lots were then counted out from the treatment lot, using care to avoid removing the chemical from the seeds while counting them. There is some error in this procedure, but it was compensated in part by using slight excesses of chemical and making periodic weighings of treated seeds.

Liquid or slurry treatments were similarly applied, except that more care was necessary to insure against excessive loss of chemical in the mixing container. Added moisture was kept as low as was consistent with adequate coverage since germination may be impaired by high moisture in the storage period preceding planting. All seed treatment materials were used undiluted except as noted.

Most of the plantings, whether in the greenhouse or field, were set up as randomized block designs and replicated a minimum of four times. In most greenhouse plantings, the flats were kept at a temperature of 40-50° F. for 5 days after planting to increase the severity of

TABLE 1—Trade names, composition, and manufacturer of seed treatment chemicals used in experiments on table beets and spinach. 1948-1953

Trade name or code number*	Active ingredient	Manufacturer
Dow 5	tetrachloro para-benzoquinone (Chloranil)	Dow Chemical Company
Dow 9	100% zinc 2,4,5-trichlorophenate	
Dow 9B	50% zinc 2,4,5-trichlorophenate	
Dow 10	trichlorophenol	
Dow F 800	50% 2,4,5-trichlorophenol chloroacetate	
Dow F 804	25% 2,4,5-trichlorophenol chloroacetate	
Arasan	50% tetramethyl thiuramdisulphide (Thiram)	E. I. duPont de Nemours
Arasan SF	75% Thiram, wettable	
Arasan SF-X	75% Thiram, wettable plus non-dusting agent	
Naugatuck Thiram	50% Thiram with non-dusting agent	Naugatuck Div., U.S. Rubber Co.
duPont I & D	56% Thiram with 14% Lindane	E. I. duPont de Nemours
Spergon	96% tetra chloro para-benzoquinone (Chloranil)	Naugatuck Div., U.S. Rubber Co.
Phygon (seed protectant)	50% 2,3-dichloro 1,4-naphthoquinone	
Phygon XL	50% Phygon, wettable	
Yellow Cuprocide	Yellow copper oxide	Rohm and Haas
Semesan Jr.	1% ethyl mercury phosphate	E. I. duPont de Nemours
New Improved Ceresan	5% ethyl mercury phosphate	
Ceresan M	7.7% ethyl mercury p-toluene sulfonanilide	
Dithane D-14	disodium ethylene bis-dithiocarbamate	Rohm and Haas
Dithane Z-78	zinc ethylene bis-dithiocarbamate	
Zerlate	76% zinc dimethyl dithiocarbamate	E. I. duPont de Nemours
Semesan	30% hydroxymercurichlorophenol	
Bioquin 1	copper 8-quinolinolate (dust)	Monsanto Chemical Co.
L-224	mercury-zinc-chromate	Carbide & Carbon Chemical Corp.
L-640	copper-zinc-chromate	
5400	reaction product of dimethyl dithiocarbamate and sulfur dichloride	
Panogen	2.2% methyl mercury dicyandiamide	Panogen Inc. (Ringwood Chemical Co.)
Panogen-S	copper 8-quinolinolate (liquid)	Panogen Inc. (Ringwood Chemical Co.)
Panogen 5202 K	50% copper 8-quinolinolate (dust)	
Panogen 5025 S	same as Panogen-S	
Vancide 51	30% of sodium salts of dimethyl dithiocarbamic acid and 2-mercaptobenzothiazole (Liquid)	Niagara Div., Food Machinery and Chemical Corp.
Orthocide 406	50% n-trichlormethylthio tetrahydrophthalimide (Captan)	California Spray-Chemical Corp.
Orthocide 75	75% Captan	
Orthocide Seed Guard	75% Captan with 16.5% Lindane	
Tritisan	20% pentachloronitrobenzene (dust)	Plant Products Corp.
Brassicol	same	
Mycon	7.7% methyl arsenic sulfide	Pittsburgh Coke & Chemical Co.
Velsicol 48-CS-36 (PX 337)	chlorinated cyclopentadiene addition compounds	Velsicol Corp.
Velsicol 48-CS-73 (PX 338)		
Fermuline	8% phenyl mercury salicylate, 10% iron octoate	H. L. Woudhuysen & Associates
Merculine	10% phenyl mercury salicylate	
Mercusol	2% phenyl mercury salicylate, 20% copper resinate	
Setrete	7% phenyl mercury ammonium acetate	W. A. Cleary Corp.
Basic copper carbonate	"Fixed" or insuluble copper compound	Tennessee Copper Corp.
Actidione	cycloheximide (antibiotic)	Upjohn Co.

*All materials furnished gratis by the manufacturers.

pre-emergence damping-off. They were then moved into a warmer location (60-80° F.) for the remainder of the growing period.

The varieties Detroit Dark Red beets[2] and Giant Noble spinach[3] were used throughout. References to all materials in these experiments is by trade name—only for the convenience of using the shorter names. Other proprietary materials with the same active ingredients are equally effective when applied properly.

TABLE BEETS

EFFECT OF STORAGE ON GERMINATION OF TREATED SEED

One of the questions that arises in seed treatment work is whether storage of treated seeds will reduce germination. There is evidence that certain materials, such as organic mercuries, may be detrimental to cereal seeds in long storage under sub-optimum conditions (Brett and Dillon-Weston, 1931). Red copper oxide and Ceresan have been reported as injurious to sugar beet seed stored with excessive moisture (Leach and Houston, 1939). A trial planting of beet seed treated in 1947 was made in 1948. Of the eight treatment materials (Dow 5, 6B, 9, 9B and 10; Arasan and Spergon), none was obviously harmful at retention dosages. Arasan- and Dow 5-treated lots produced better stands than did the control. Other lots of the seeds were planted for comparison with seeds freshly treated with the same materials. No differences in germination attributable to time of treatment were found.

A storage experiment was begun in 1948 involving seeds destined for planting in the field in 1949. Enough seeds were set aside so that duplicated treatments could be made shortly before planting time and at the same rates of application. All seeds, both treated and those left for later treatment, were stored in the laboratory. A small remainder of seeds from the various lots was held for a second planting in 1951. All of the treatments were applied as dusts. Stands of young plants surviving the seedling stage were taken. The germination rates were low—between 12 and 38 plants per 100 seedballs. An analysis of the data showed that storage was not a determining factor in seedling stands. There were slight variations in the stands of seeds treated in 1948 and 1949, but neither was consistently higher. Stands for the Phygon treatment were significantly higher than those of the controls. The second planting, made in 1951, gave similar results. Two materials,

[2]Ferry-Morse Seed Co., Detroit, Mich.
[3]*Ibid.*

Arasan and Phygon, gave good control of damping-off, and stands were similar for the 1948 and 1949 treated lots of seed. Other treated seed had relatively lower stands than in the previous planting. According to these results, prolonged storage of treated seed is not harmful to germination.

GREENHOUSE EXPERIMENTS ON MATERIALS AND RATES OF APPLICATION

During the winter of 1949-50, an experiment was performed to study the effects of several seed treatment fungicides, their rates of application, the method of application (wet[4] or dry), and interactions of these factors. Four materials were used at rates of 4 and 8 ounces/100 pounds of seed: Phygon XL, Arasan SF., Yellow Cuprocide, and Dow F-800. The seedling counts (Table 2) are for emergence only,

*TABLE 2—Emergence of table beet seedlings from seeds treated with four fungicides at two rates of application by dry and wet methods**

Treatment	Rate, oz./100 lb. seed	Method of application		Average both methods	Fungicide average
		Dry	Wet		
		%	%	%	%
Arasan SF.....	8	21.5	19.2	20.3	16.4
Phygon XL.....	8	20.7	17.7	19.2	15.0
Dow F 800.....	8	10.2	25.3	17.7	14.4
Arasan SF.....	4	3.3	21.7	12.5	....
Dow F 800.....	4	11.0	11.2	11.1	....
Phygon XL.....	4	9.0	12.7	10.8	....
Control.....	4	4.8	5.3	5.1	4.5
Control.....	8	4.7	3.3	4.0	....
Yellow Cupro.....	8	3.5	3.0	3.2	2.9
Yellow Cupro.....	4	3.3	1.8	2.6	....
L.S.D. (0.05).....	..	7.6		4.4	3.6
L.S.D. (0.01).....	..	10.1		6.0	4.9

*Average of six replications, 50 seedballs each. Emergence to 38 days after planting.

and the data thus concern only pre-emergence damping-off. All emerged plants were counted and removed within 3 days after the cotyledons unfolded. Analysis of the data shows that the 8-ounce applications were superior to the 4-ounce and that the wet method was superior to the dry. Arasan SF, Phygon XL, and Dow F-800 gave statistically significant results in damping-off control at either or both

[4]A 5-percent methyl cellulose solution.

rates of application, but only Arasan SF was consistently superior at most rates and with the methods of application. The rates were too low for effective protection with Yellow Cuprocide as shown by later work (Table 3).

TABLE 3—Comparison of Acti-dione seed treatment of table beets with standard seed treatment fungicides

Treatment	Rate, percent of seed weight	Post-emerg. damping-off*	Healthy plants	Total emerg.
A. Four-percent Acti-dione	%	%	%	%
Acti-dione (4%)	0.9	17.2	42.7	59.9
Arasan	1.0	30.0	96.4	126.4
Phygon XL	1.5	32.6	111.1	143.7
Vancide 51	3.0	15.0	111.1	126.1
Yellow Cuprocide	2.3	39.8	77.3	117.1
Control (talc)	0.8	14.6	0.5	15.1
L.S.D. (0.05)	...	....	15.4	10.5
L.S.D. (0.01)	...	....	20.6	14.0
B. Acti-dione at ¼, ½, and 1 percent				
Acti-dione (1%)	...	89.3†	6.5	95.8
(½%)	...	64.5	0.2	64.7
(¼%)	...	57.8	2.0	59.8
Arasan	...	79.7	36.8	116.5
Orthocide 406	...	95.5	21.0	116.5
Phygon XL	...	77.3	35.2	112.5
Vancide 51	...	64.0	47.2	111.2
Control (talc)	...	37.0	2.2	39.2
L.S D. (0.05)	...	....	18.7	12.8
L.S.D. (0.01)	...	....	25.0	17.1

*Average of ten replications, 100 seedballs each.
†Average of six replications, 100 seedballs each.

During 1952 two greenhouse experiments were made with table beets to compare the action of an antibiotic (Actidione, ferrated) with four standard seed treatment materials. This material has been used successfully in the treatment of covered smut of wheat (Henry, Millar and Peterson, 1952). In the first experiment, maximum retention dosages of all dry materials were used in order to determine the safety factors (Table 3, Part A). Vancide 51, a liquid material, was used at 3 percent of seed weight so that it would be roughly equal to the active ingredients of the dusts. Notes were made on post-emergence damping-off, total emergence and final stands of healthy

Fig. 1. Seed treatment of table beets—1952. Left to right: the effects of no treatment (26), Arasan (27), Acti-dione (28), Vancide 51 (29), and Phygon XL (30) on stands 26 days after planting. Note the stunting and poor stand in the Acti-dione rows (28). Photograph by Philip G. Coleman.

plants at the conclusion of the experiment (Table 3-A). Acti-dione, at several strengths, was used in the second experiment in comparison with standard materials (Table 3, Part B).

All materials controlled damping-off significantly. Four-percent Acti-dione was inferior to the other fungicides for both pre-emergence and post-emergence control. In addition, it caused seedling injury at the rate used. Many seedlings were distorted and had poor color and vigor in the early stages of growth (Fig. 1). All materials gave statistically significant control of damping-off in these trials, and Arasan, Orthocide 406, Phygon XL, and Vancide 51 were also significantly better protectants than Acti-dione. Because Acti-dione, at least in this form, was neither very effective nor safe for use on table beet seed, its use was discontinued.

FIELD EXPERIMENTS

Field experiments to screen the seed treatment fungicides were begun in 1948. In the first of these, five materials were tested each at two different rates. Stands of healthy plants were determined 48 days after planting (Table 4: 1948). A larger trial with 15 materials was made in 1950. Stands in this planting were determined 32 days after planting (Table 4: 1950). In 1952, 15 materials were used. The treatments were made about a month before planting and the plot

TABLE 4—Seed treatment of table beets, four years' trials

Treatment	Rate, oz./100 lb.	Stands			
		1948*	1950†	1952†	1953†
		%	%	%	%
Acti-dione (1 percent)	16	....	....	10.5	....
Arasan	4	53.8	....	....	....
Arasan	8	59.4	62.3	25.8	34.8
Arasan SF	8	....	49.5	....	....
Arasan SF-X	8	....	....	27.5	44.7
Basic CuCO3	16	....	....	....	29.3
Bioquin-1	8	....	36.0	....	....
Brassicol	8	....	....	....	22.2
Ceresan M	4	....	50.2	23.8	....
Dithane D-14	16	....	....	18.3	....
Dithane Z-78	8	....	53.5	15.2	....
Dow 9B	4	28.4	....	....	....
Dow 9B	8	38.8	....	....	....
Dow F-800	4	32.8	....	....	....
Dow F-800	8	26.6	....	....	....
Dow F-804	4	28.6	....	....	....
Dow F-804	8	27.0	....	....	....
duPont I & D	8	....	....	....	39.5
Fermuline	6	....	....	....	33.2
L-224	8	....	26.5	....	23.3
L-640	8	....	35.8	19.5	26.0
5400	8	....	48.0	20.0	....
Merculine	6	....	....	....	35.0
Mercusol	6	....	....	....	22.5
Mycon	8	....	....	....	15.0
Naugatuck Thiram	8	....	....	....	36.7
Ortho. 75 or 406	6 or 8	....	....	22.0	42.0
Ortho. Seed Guard	6	....	....	....	44.3
Panogen (Regular)	4 or 6	....	29.3	....	37.5
Panogen (Regular)	12	....	....	....	55.0
Panogen-S (5025-S)	4	....	80.3	....	....
Panogen-S (5025-S)	8	....	....	28.8	37.3
Panogen 5202-K	8	....	....	....	15.0
Phygon	8	63.6	....	....	42.5
Phygon	16	86.0	....	....	....
Phygon XL (dry)	8	....	53.5	23.8	....
Phygon XL (slurry)	8	....	....	30.8	....
Semesan	4	....	....	15.0	12.3
Semesan Jr.	4	....	47.3	....	....
Spergon	8	....	31.8	....	25.0
Setrete	6	....	....	....	29.3
Tritisan	8	....	....	....	14.7
Vancide 51	16	....	....	20.2	16.2

TABLE 4—Continued

Treatment	Rate, oz /100 lb.	Stands			
		1948*	1950†	1952†	1953†
		%	%	%	%
Velsicol 48-CS-36	8	....	....	....	16.2
Velsicol 48-CS-73	8	....	....	....	21.5
Yellow Cuprocide	8	....	37.8	....	....
Zerlate	8	....	47.5	17.5	....
Control (no treatment)	..	30.8	44.2	16.2	17.5
L.S.D. (0.05)	..	15.2	22.3	10.2	14.2
L S D. (0.01)	..	20.4	29.7	13.6	18.7

*Average of five replications, 100 seedballs each.
†Average of six replications, 100 seedballs each.

was seeded late. In spite of the late planting and the low average stands, the results were consistent enough to allow statistical interpretation of the data (Table 4: 1952). The 1953 trial included 25 materials. Stand counts of healthy seedlings, 24 days after planting, are given in Table 4: 1953.

Analysis of the data shows that Phygon and Arasan gave highly significant control of damping-off in 1948; only Panogen-S in 1950; Phygon XL, Panogen-S and Arasan SF-X were effective in spite of low average stands in 1952; and Panogen (Regular), Arasan SF-X, Orthocide Seed Guard, Phygon, Orthocide 75, I and D, Panogen 5025-S and Naugatuck Thiram were highly effective in 1953. Merculine and Fermuline gave statistically significant control of damping-off of a lower order.

Several things of interest appear in the data for 1953. Twelve of the treatments gave significant control of damping-off compared with no treatment, and also there are significant differences within the effective group. The 12-ounce rate of Panogen, for instance, was superior to the 6-ounce rate. This material, even though it is a highly volatile and potent organic mercury compound could be tolerated by beets and used effectively at high rates. Fermuline and Merculine were less effective but were also used at lower rates. Further testing of these materials is needed. Panogen 5025-S (identical with Panogens-S) used in 1953 was less effective comparatively than in 1950 and 1952.

SPINACH

EFFECTS OF STORAGE ON TREATED SEED

To observe the effects on germination and protection against damping-off, spinach seed treated in 1947 was tested in 1948 in comparison with freshly treated seed from the same lot. Six materials were used. Total emergence and final stands, 24 days after planting, were determined. There were no obvious differences in emergence or final stand due to time of treatment, but all of the materials aided emergence. In the next experiment seven materials applied in 1947 were compared with those applied in 1948. In this case the freshly treated seeds were benefitted, in respect to final stands, by applications of Arasan, Yellow Cuprocide and Semesan Jr., whereas those treated a year before planting were not. Spergon, Dow 10, and Dow 5 (Chloranil as in Spergon) were injurious in this test when treated seeds were stored for a year.

Since the preliminary trials were partly inconclusive, it was decided to make a larger field planting in an attempt to determine the effects of storage. One lot of seed for each treatment was treated in 1948 and saved until 1949. Before planting time the other lot was given the same treatment. Remainders were saved for planting in the greenhouse in 1951 (Table 5). There were no significant changes in stand due to year of treatment or interaction between year and fungicide in the field trial. Phygon, used at the rate of 8 ounces, and Yellow Cuprocide, at the rate of 16 ounces, gave significant control of damping-off. Although the total stands were extremely low and would not be commercially profitable, the results are in agreement with the work of others in which copper materials were highly effective (Cook and Callenbach, 1935; Cook, 1937; Foster, 1947). The data on emergence in the 1951 greenhouse test (Table 5) are for two and three years' storage. These results agree in most particulars with those of the previous field planting. The prolonged storage had no ill effects on spinach seed treated with Yellow Cuprocide, Phygon, or Arasan. Spergon failed to protect the seeds adequately in the field trial but was effective later on in the greenhouse with the same treated lots. Arasan, which had little effect in the field trial, was the best of the treatments in the greenhouse two years later. Apparently the results of the 1949 test were influenced by excessive field variability and post-emergence killing of the seedlings. Under more favorable conditions, several of the

TABLE 5—Stand of spinach seedlings from seed treated one, two, and three years before planting as compared with that from freshly treated seeds, in percentage

Treatment	Rate, oz./100 lb.	Percent stands 1949*			Percent stands 1951†		
		Treated 1948	Treated 1949	Average both years	Treated 1948	Treated 1949	Average both years
		%	%	%	%	%	%
Arasan	4	21.2	14.7	18.0	66	79	72.5
Arasan	8	23.2	24.0	23.6	67	69	68.0
Dow 9B	4	14.2	12.0	13.1	7	2	4.5
Dow 9B	8	27.2	14.7	21.0	5	3	4.0
Dow F-800	4	10.7	11.7	11.2	13	9	11.0
Dow F-800	8	19.5	21.7	20.6	8	5	6.5
Dow F-804	4	18.2	19.0	18.6	1	8	4.5
Dow F-804	8	12.7	15.7	14.2	7	6	6.5
New Impr. Ceresan	1	12.5	11.0	11.7	17	5	11.0
New Impr. Ceresan	2	18.7	17.0	17.9	24	18	21.0
Phygon	8	22.2	30.0	26.1	58	63	60.5
Phygon	16	19.7	27.5	23.6	58	61	59.5
Spergon	4	14.7	13.5	14.1	15	32	23.5
Spergon	8	13.7	16.0	14.9	43	26	34.5
Yellow Cuprocide	8	20.2	21.7	21.0	52	57	54.5
Yellow Cuprocide	16	27.2	24.7	26.0	69	69	69.0
Control (no treatment)	..	14.5	18.7	16.6	14	15	14.5
L.S.D. (0.05)	..	....	....	8.4	..	..	....
L.S.D. (0.01)	..	....	....	11.2	..	..	....

*Average of four replications, field planting.
†One replication, greenhouse planting.

materials, such as Arasan, would have been beneficial. The other materials used were not satisfactory for spinach.

One experiment, in addition to the storage experiments, was made in the greenhouse in 1950 to confirm the relative efficacy of Yellow Cuprocide, Arasan SF and Phygon applied dry and as slurry. Damping-off was very severe in this experiment, but Phygon XL, Yellow Cuprocide, and Arasan SF were all effective in control. Slurry application offered little or no added protection over the use of the dry fungicide where sufficient material adhered to the seed. Recently Leukel (1953) came to a similar conclusion in work on spring wheat and oats.

FIELD EXPERIMENTS

Field experiments on seed treatment of spinach were made in 1948, 1950, and 1953. The 1948 experiment was the only one in which the

stands were large enough to produce valid results. In 1950 and 1953, weeds, poor soil conditions, and unfavorable weather generally combined with heavy damping-off to reduce stands to 10 percent or less. In 1948, eight materials were used at two rates for each material. The seeds were planted within two weeks of treating and notes on stands taken 27 days later (Table 6). Yellow Cuprocide, Arasan, and Phygon

TABLE 6—Percent stands of spinach from seed treated with eight seed treatment fungicides at two rates of application

Treatment	Rate, oz./100 lb. seed	Percent*
Arasan	8	59.8
Yellow Cuprocide	8	59.6
Yellow Cuprocide	16	57.6
Phygon	8	55.0
Arasan	4	51.8
Phygon	16	50.8
Dow 9B	4	50.0
New Improved Ceresan	2	47.0
Dow 9B	8	46.8
Spergon	8	45.4
Dow F-800	8	45.0
Dow F-804	8	44.8
New Improved Ceresan	1	42.4
Dow F-804	4	41.2
Spergon	4	39.2
Dow F-800	4	38.6
Control—no treatment	..	38.6
L.S.D. (0.05)	..	12.1
L.S.D. (0.01)	..	16.1

*Average of five replications, each 100 seeds.

were the three most effective seed protectants in this trial. The 8-ounce application of Arasan was better than the 4; 8 ounces of Phygon better than 16; and 8 ounces of Yellow Cuprocide slightly better than the 16 for that year.

DISCUSSION

A few seed treatment materials were consistently superior for use on table beets and spinach. Phygon (or Phygon XL) and Arasan (or Arasan SF) were thoroughly tested and found highly effective on both varieties. Yellow Cuprocide was the best of the materials for use on spinach, but was only fair in respect to beets. This material was very specific in its applicability in spinach seed treatment, a fact in agreement with the literature (Davis and Haenseler, 1943; Pirone *et al.*,

1933). Both Yellow Cuprocide and Spergon were distinctly inferior to Arasan and Phygon for beet seed treatment.

Several other materials, such as Panogen, Panogen-S (5025-S), Orthocide (Captan), Orthocide Seed Guard, duPont I and D, Merculine and Fermuline, still have not received adequate testing. This group of materials is promising in view of the results obtained. It is quite likely that larger dosages of several of these materials would give more effective seed protection as was true in the case of Panogen on beets. Vancide 51 was not so effective as the Arasan and Phygon materials. It is a material of intermediate value in that it may give effective seed protection but will not save as many seeds under the same conditions.

Experiments on the effect of storage of treated beet and spinach seeds gave mostly negative results. The conditions of storage were favorable for seed preservation, and no reduction or increase in germination rate could be attributed to prolonged storage of the treated seeds. These findings are in agreement with other research reports (Brett and Dillon-Weston, 1941; Henry, Millar and Peterson, 1952; Leach and Houston, 1939) where injury was usually associated with poor storage conditions rather than the treatment chemical.

SUMMARY

The report covers experiments and screening tests made with 45 seed treatment fungicides for the control of damping-off of table beets (Detroit Dark Red) and spinach (Giant Noble) between 1948 and 1953. Of these materials, Phygon (XL), and Arasan (SF) were the most consistently effective for use on beets. Yellow Cuprocide was less effective. Yellow Cuprocide was slightly better than Arasan and Phygon on spinach. On the basis of fewer tests, Panogen, Panogen-S, Orthocide (75), Orthocide Seed Guard, duPont I and D, Merculine and Fermuline, were also promising. Vancide 51 was less effective than Arasan and Phygon. The antibiotic Acti-dione was toxic to beet seeds at strengths from 1 to 4 percent and was ineffective as a seed protectant at all strengths. Storage of treated seeds of beets and spinach was not detrimental to germination when seeds were stored in the laboratory.

Recommendations based on the results of the trials are: Phygon (50 percent active) or Arasan (75 percent active) at 8 ounces/100 pounds seed, either dry or as a slurry. These two materials are satisfactory for both beets and spinach. Yellow Cuprocide at 8 ounces/100 pounds is superior for treatment of spinach seed.

LITERATURE CITED

Brett, C. C., and W. A. R. Dillon-Weston (1941). Seed disinfection. IV. Loss of vitality during storage of grain treated with organo-mercury seed disinfectants. Jour. Agr. Sci. *31:* 500-517.

Brett, C. C., and W. A. R. Dillon-Weston (1931). Vegetable seed treatment. N. Y. (Geneva) Agr. Expt. Sta. Bul. 597.

Cook, H. T., and J. A. Callenbach (1935). Spinach seed treatment. Va. Truck Expt. Sta. Bul. 87.

Cook, H. T. (1937). Spinach and cabbage seed treatment. Va. Truck Expt. Sta. Bul. 96.

Davis, B. H., and C. M. Haenseler (1943). Tests with some vegetable seed protectants. U. S. Dept. Agr. Pl. Dis. Rptr. *27:* 170-173.

Foster, Aubrey Alfred (1947). Acceleration and retardation of germination of some vegetable seeds resulting from treatment with copper fungicides. Phytopath. *37:* 390-398.

Gould, C. J. (1943). Vegetable seed-treatment tests in western Washington. U. S. Dept. Agr. Pl. Dis. Rptr. *27:* 594-601.

Henry, A. W., R. L. Millar, and E. A. Peterson (1952). Control of covered smut of wheat by rapid seed treatment with an antibiotic. Science *115:* 90-91.

Leach, L. D., and B. R. Houston (1939). Influence of moisture and other factors on the efficiency and safety of sugar-beet seed treatment. Phytopath. (abst.) *29:* 15.

Leach, L. D. (1940). Influence of the pathogen, environment, and host response on the efficacy of seed treatment with sugar beets and some vegetable crops. Phytopath. (abst.) *30:* 788.

Leukel, R. W. (1948). Recent developments in seed treatment. Bot. Rev. *14:* 235-269.

Leukel, R. W. (1953). Cooperative tests of seed-treatment chemicals on Spring wheat and oats in 1953. U. S. Dept. Agr. Pl. Dis. Rptr. *37:* 587-594.

Pirone, P. P. *et al.* (1933). Copper seed treatments for the control of damping-off of spinach. N. Y. (Cornell) Agr. Expt. Sta. Bul. 556.

Taylor, Carlton F., and Joseph A. Rupert (1946). A study of vegetable seed protectants. Phytopath. *36:* 726-749.

Walker, J. C. (1948). Vegetable seed treatment. Bot. Rev. *14:* 588-601.

THE PALATABILITY OF HAY CROP SILAGE TREATED WITH SODIUM BISULFITE[1]

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THE PALATABILITY of hay crop silage treated with sodium bisulfite was compared with that of untreated hay crop silage in a free-choice type of feeding trial. The comparative palatabilities of the materials used in this study do not measure their economic or nutritional values; however, the matter of heifer preference for hay crop silage treated with sodium bisulfite is indicated.

A quantity of sodium bisulfite was supplied by the Monsanto Chemical Company for the 1953 forage ensiling at the Upper Peninsula Experiment Station.

This new powdered preservative was applied manually at the rate of approximately 8 pounds per ton upon the green forage[2] lengthwise in the north half-section of the concrete trench silo.[3] This was accomplished by weighing loads of the green forage and spreading 2 pounds of the preservative over each estimated 500 pounds of forage fill in the section of the silo treated. The preservative was used on 50 tons of forage.

PALATABILITY TRIAL

The palatability of the hay crop silage treated with sodium bisulfite was compared with that of untreated hay crop silage in an 8-day trial conducted as follows: With the use of a 16-foot silage manger divided in the center, eight Holstein heifers, ranging in age from 19 to 28 months, were confined in a penned area and fed only silage.

The heifers were fed once each day, one-half the manger being filled with the bisulfite-treated silage, and the other half with the untreated silage. All heifers had free access to both ends of the

[1]Chemical determinations were made under the direction of Dr. E. J. Benne, Department of Agricultural Chemistry.

[2]Forage harvested from June 22 to 27, 1953 at an average moisture content of 76.5 percent. Ensiled hay crop consisted of grass legume mixture, averaging over 65 percent grasses.

[3]Silo dimensions: Length—64 feet; height—9 feet; top width—9 feet; bottom width—8 feet.

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manger. The feeding of silage was regulated so that any refused amount of each kind was weighed back each day prior to reversing the feeding sections of the manger for the next 24-hour period.

Drinking water was available at all times. Sawdust was used as bedding material.

During the 8-day trial the average daily intake of silage per heifer was 97.8 pounds. The average daily intake of bisulfite-treated silage was 55.4 pounds, as compared with a daily intake of 42.4 pounds of untreated silage (Table 1).

TABLE 1—Consumption of bisulfite-treated and untreated hay crop silages by eight heifers for eight days

Date	Day of trial	Total amount of silage consumed per day		Silage consumed per heifer per day		Total
		Bisulfite	Untreated	Bisulfite	Untreated	
		Lb.	*Lb.*	*Lb.*	*Lb.*	*Lb.*
November 6	1st	462	306	57.7	38.2	95.9
" 7	2nd	510	468	63.7	58.5	122.2
" 8	3rd	517	387	64.6	48.3	112.9
" 9	4th	386	334	48.2	41.7	89.9
" 10	5th	437	283	54.6	35.3	89.9
" 11	6th	435	282	54.3	35.2	89.5
" 12	7th	471	345	58.8	43.1	101.9
" 13	8th	325	310	40.6	38.7	79.3
Average.....		442.9	339.3	55.4	42.4	97.8

OBSERVATIONS AND RESULTS

1. Silage preserved with sodium bisulfite was lighter green and had a sharp, fresh, green-grass smell.

2. The silage near the floor of the silo in both the untreated and the treated sections was uniformly darker; the treated silage, however, could still be distinguished by its sharp, pleasing odor.

3. The treated silage was more uniform in color from top to bottom of the trench silo.

4. Heifer preference for the hay crop silage treated with sodium bisulfite and which was fed on a free-choice basis was indicated by a greater daily intake of the treated silage. Of the total daily intake of 97.8 pounds, 55.4 pounds of treated silage was consumed as compared with an intake of 42.4 pounds of the untreated silage.

5. No marked difference in chemical composition was discovered due to preservation with sodium bisulfite (see Table 2).

TABLE 2—Chemical composition of silages

Silage	Ash	Crude fiber	Ether extract	Water	Protein	N-Free extract	pH
	%	%	%	%	%	%	%
Not treated with sodium bisulfite....	1.59	8.54	0.86	74.69	3.64	10.68	5.25
Treated with sodium bisulfite....	1.84	8.57	0.86	74.14	3.63	10.96	5.00

6. The sodium bisulfite was supplied in 100-pound heavy paper bags. It was free flowing, and no difficulty occurred in spreading it in the trench silo by hand.

THE EFFECT OF VARIOUS PLANTING DISTANCES ON THE PRODUCTIVITY AND QUALITY OF FLOWERS PRODUCED BY THE HAPPINESS VARIETY OF GREENHOUSE ROSE

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THE HAPPINESS VARIETY of greenhouse rose generally is not grown because of its lack of productivity. The number of flowers produced, as reported by commercial greenhouse operators, varies from one-half to one-third the number produced by the more commonly grown varieties. Although this rose variety lacks productivity it is generally conceded to be one of the best of the red roses available today. Another desirable characteristic is its strong vegetative vigor which produces long-stem premium roses.

The object of the investigation reported in this article was to determine the effect of various planting distances on the number and quality of the flowers produced by these plants and, thus, to increase productivity.

EXPERIMENTAL METHODS

On May 1, 1952 budded rose bushes were selected for uniformity and were planted in well prepared greenhouse soil. Planting distances were the conventionally accepted 12 by 12 inches and, also, 9 by 12 inches. This closer spacing made possible an increase of approximately 30 percent in the number of plants grown in a given area. Experimental plots were 40 square feet in area, and the treatments were randomized and replicated.

All flowering shoots were soft pinched in the early development of the plants, and the production data for the first year were collected from July 1, 1952 through March 31, 1953. During the spring of 1953 the plants were made dormant by withholding water and then were cut back to a height of 24 inches. The ensuing new growth was soft pinched. Production data for the second year were collected for the same period as during the preceding year. Flowers were cut in the

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usual commercial manner and were graded according to the following stem lengths which included the length from the cut end to the base of the flower:

Three	9 inches
Two	9-12 inches
One	12-15 inches
Extra	15-18 inches
Fancy	18-24 inches
Special	24 inches and over
Cull	bullheads and unsaleable

Accepted commercial cultural practices were maintained at all times.

RESULTS AND DISCUSSION

The effect of the various planting distances on the productivity and quality of flowers produced by the rose is indicated in Table 1.

TABLE 1—The relationship of various planting distances to the production and quality of flowers produced by the Happiness variety of greenhouse rose*

Planting distance, inches	Total number flowers per 40 sq. ft.	Average number flowers per plant	Yield of flowers by grade, in percent					
			Three	Two	One	Extra	Fancy	Special
			%	%	%	%	%	%
July 1, 1952 to March 31, 1953								
9 x 12...	500	9.6	8.5	16.5	17.8	14.6	23.3	19.3
12 x 12...	457	11.4	8.8	16.3	18.1	14.0	23.2	19.6
July 1, 1953 to March 31, 1954								
9 x 12...	652	12.6	0.3	4.2	12.5	22.3	44.0	16.7
12 x 12...	591	14.8	0.3	4.9	12.4	19.0	44.0	19.4

*Planting distance 9 x 12 accommodated 52 plants per 40 square feet.
Planting distance 12 x 12 accommodated 40 plants per 40 square feet.

These data reveal that reducing the planting distance from 12 x 12 inches to 9 x 12 inches resulted in an increase in the number of roses produced per unit area. For 1952-53 and 1953-54 this increased productivity was 9.4 and 10.3 percent, respectively.

Not only was the production of flowers increased by the closer planting, but there was also no apparent deleterious effect on the quality of the roses produced. Of the total number of flowers produced during 1952-53 by plants spaced 9 x 12 inches as compared with those spaced 12 x 12 inches, 57.2 and 56.8 percent, respectively, were of the grade of extra or better. Comparable data for the similar period during 1953-54 were 83.1 and 82.4 percent. Thus, for the two years there was seemingly no significant difference in the quality of the flowers as influenced by the planting distance. The greater number of roses of better grade produced the second year was probably the result of planting the bushes in May. The flush of the first year's growth occurred during hot weather, which resulted in short-stemmed roses.

The practical aspect of the foregoing considerations may be stated very simply. An increase of approximately 30 percent in the number of plants per unit of bench area resulted in approximately a 10-percent increase in production without any apparent reduction in the quality of the flowers produced. The economic feasibility of closer planting will depend on the initial cost of the rose bushes as well as the return a grower receives for his flowers.

PASTURE RESULTS WITH STEERS ON REED CANARYGRASS

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REED CANARYGRASS, as a pasture plant, is well adapted to wet or flooded organic soils. Because such sites are adequately supplied with moisture, the grass remains productive throughout the pasture season and remains so for many years without reseeding.

Several million acres of such land are available in Michigan, and reed canarygrass would do much to alleviate the summer pasture problem if it could be managed properly and fitted into the pasture program.

Conflicting observations as to its value as pasture for certain types of livestock are a common occurrence. Most reports agree that it has a high livestock-carrying capacity and a long season use, although some state that the animals have an unthrifty appearance and a low rate of gain. Most favorable reports are those where dairy cows are fed grain or where access to other pasture is provided.

The project reported in this article was started in an attempt to determine how steers would respond when pastured continuously on reed canarygrass.

EXPERIMENTAL AREA

The experiment was located on the College farm. The soil is classified as Carlisle muck, having a pH of 6.5-7.0 and being approximately 6 feet deep. It was plowed, fitted, and divided into six 1-acre areas for various fertilizer treatments in the summer of 1949. The treatments, replicated twice, were as follows: unfertilized (plots 2 and 5); 500 pounds of 0-10-30 (plots 3 and 6); and 500 pounds of 0-10-30 plus minor elements (plots 1 and 4). One hundred pounds of technical grade manganese sulfate and 50 pounds of copper sulfate per acre

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were applied in 1949, 1951, and 1952. The 0-10-30 fertilizer was applied annually at the rate of 500 pounds per acre. An additional 4-acre area at the Muck Experiment Farm was similarly fertilized and used as a hay source for winter feed.

The area was seeded in August at the rate of 5 pounds of reed canarygrass seed per acre—the drill being set to deliver 12 pounds of sweet clover seed per acre.

A good seeding was established on the entire area, and an early response to the fertilizer was noted. The following spring, the one-acre areas were individually fenced, and on June 13, 1950 yearling steers were turned onto the plots. Earlier pasturing was delayed because of limited forage growth (from the previous August seeding) and because excessive soil moisture delayed fencing. The steers were a uniform group of choice quality Herefords, in good feeder cattle flesh, and weighing an average of 540 pounds.

EXPERIMENTAL RESULTS

The results of the four years' work (1950 through 1953) are reported in Tables 1, 2, 3, and 4.

To determine the carrying capacity of the plots for yearling steers, four steers each were placed on plots 1, 3, and 4; three each on plots 2 and 5; and five steers on plot 6. During the early part of the 1950 grazing season, the results indicated a carrying capacity of two yearling steers per plot. Thus, the data reported in Table 1 include only that obtained on two steers per plot. The range in weight gained or lost among the 12 steers during the 120-day grazing period was from a loss of 35 pounds to a gain of 70 pounds, with four steers losing weight and only one gaining more than 40 pounds.

During the winter of 1950-51 the steers were fed reed canarygrass hay for 130 days and corn silage and mixed hay for 84 days. They were turned to pasture as two-year-olds the following spring on May 15 and were in much thinner flesh than when purchased in 1950. It became evident during the summer that the one-acre plots would not carry two two-year-old steers. The results are reported accordingly in Table 2 for the 1951 grazing season. Steers that completed the 127-day grazing period ranged in total weight gain from 0 to 185 pounds. The average gain made by those steers completing the grazing

TABLE 1—Yearling steers on reed canarygrass given varying soil treatments, 120 days—1950

Plot	Soil treatment	Steer* number	Initial weight June 13, lb.	Final weight Oct. 13, lb.	Total gain, lb.
	0-10-30 + minor elements				
1		16	580	580	0
		35	550	620	70
4		17	590	585	− 5
		62	530	560	30
	No fertilizer				
2		46	630	595	−35
		58	560	560	0
5		19	580	620	40
		50	645	645	0
	0-10-30				
3		37	575	560	−15
		52	555	575	20
6		6	600	620	20
		29	620	615	− 5
Average			585	595	10

*Steers on plots 4, 5, and 6 had free access to iodized salt. Those on plots 1, 2, and 3 also had access to iodized salt until Oct. 16, at which time they were changed to trace mineralized salt containing in addition to salt, traces of the following minerals: iodine, manganese, copper, iron, and cobalt.

period was 76 pounds or 0.6 pound daily; those removed earlier gained slightly more. Their thinner flesh, as noted above, was one factor to be considered in evaluating the larger gains of the 1951 season as compared with the 1950 season. Steers on the unfertilized plots made the least gains.

Thin yearling steers were purchased for the 1952 grazing season in early January and were fed reed canarygrass hay until turned to pasture on May 23. The gains per steer are reported in Table 3. After one month, the steers on plots 1, 2, and 3 had lost weight, while those on plots 4, 5, and 6 had gained. At that time, the steers on the first three plots were given supplements and were rotated each two weeks among the plots to rule out the possible effect of soil treatment. The supplements were as follows: a mixture of equal parts dicalcium phos-

TABLE 2—Two-year-old steers on reed canarygrass given varying soil treatments, 127 days—1951

Plot	Soil treatment	Steer* number	Initial weight May 15, lb.	Final weight, lb.		Total gain, lb.
				Sept. 9	Oct. 19	
1	0-10-30 + minor elements	16	775	885	...	110 (86 days)
		35	755	...	925	170 (127 days)
4		17	785	Removed June 12, '51		
		62	735	...	920	185 (127 days)
2	No fertilizer	46	790	785	...	−5 (86 days)
		58	760	...	785	25 (127 days)
5		19	865	Removed June 12, '51		
		50	895	...	895	0
3	0-10-30	37	770	870	...	100 (86 days)
		52	755	...	785	30 (127 days)
6		6	810	895	...	85 (86 days)
		29	815	...	860	45 (127 days)
Average			793	858	861	76 (127 days) 73 (86 days)
Average daily gain			...	...	...	0.6 (127 days) 0.85 (86 days)

*Iodized salt supplied—free choice.

phate and iodized salt for the steers on plot 1; 1½ pounds of soybean oil meal per steer daily for those on plot 2; and 1½ pounds of corn per steer daily for those on plot 3. The supplements were fed to test the effect of adding phosphorus, protein or energy to that already present in the forage. Each steer on plot 2, fed the protein supplement, gained an average of 1.82 pounds each day for the rest of the grazing season. Chemical analyses of the forage indicated the presence of sufficient nitrogen to meet the protein requirements of the steers. Steers fed the other two supplements did not make gains greater than those without supplement on plots 4 and 6. A considerable amount of white clover and bluegrass had volunteered in plots 4 and 6, because of the com-

TABLE 3—Yearling steers on reed canarygrass given varying soil treatments, 121 days—1952

Plot	Soil treatment	Supplement fed daily	Steer* number	Initial weight May 23, lb.	Final weight Sept. 22, lb.	Total gain, lb.
1	0-10-30 + minor elements	Mineral-mix free-choice	25	605	740	135
			65	460	525	65
4			23	490	685	195
			62	470	590	120
2	No fertilizer	Soybean oil meal—1½ lb. per steer	3	450	600	150
			39	545	705	160
5			19	485	565	80
			35	500	560	60
3	0-10-30	Corn—1½ lb. per steer	17	510	595	85
			46	440	555	115
6			45	530	660	130
			56	460	615	155
Average				495	616	121
Average daily gain						1.0

* All steers had free access to iodized salt until July 16, at which time they were changed to trace mineralized salt.

bined effect of fertilizer practices and grazing management, and may have had some effect on steer gains.

The range in total gain among all steers for the 121-day grazing period, irrespective of plot treatment or steer supplementation, was from 60 to 195 pounds. The steers on the unfertilized plot not receiving supplement (plot 5) again made the least total gain. The average gain per steer on all plots for the season was 121 pounds or 1.0 pound daily.

The results for the 1953 grazing season are found in Table 4.

Yearling steers in thin flesh were purchased for the 1953 grazing season. The steers were fed reed canarygrass hay for one month before they were turned to pasture May 19. Owing to previously poor results and the fact that forage analyses showed the forage to have a low cobalt content, (0.05 p. p. m.)—along with the presence of molyb-

TABLE 4—Yearling steers on reed canarygrass given varying soil treatments, 128 days—1953

Plot	Soil treatment	Supplement fed daily*	Steer number	Initial weight May 20, lb.	Final weight Sept. 26, lb.	Total gain, lb.
1	0-10-30 + minor elements	Mineral mix	1	533	698	165
			3	625	791	166
4		Iodized salt	34	603	721	118
			37	565	736	171
2	No fertilizer	Mineral mix	16	619	684	65
			17	553	651	98
5		Mineral mix and soybean oil meal	41	592	719	127
			46	572	653	81
3	0-10-30	Mineral mix	23	607	787	180
			25	554	743	189
6		Mineral mix	50	579	685	106
			55	574	764	190
Average				581	719	138
Average daily gain						1.08

*Iodized salt was furnished free choice to steers on plot 4. Steers on the other plots had free access to a mixture composed of approximately 51.0 percent dicalcium phosphate, 45.6 percent iodized salt, 2.5 percent pulverized copper sulfate, 0.8 percent copper oxide and 0.1 percent cobalt acetate.

denum (6.0 p. p. m.)[1] which possibly was sufficient to render unavailable the copper in the forage—a mineral mixture was devised for supplementation. This contained 51.0 percent dicalcium phosphate, 45.6 percent iodized salt, 2.5 percent pulverized copper sulfate, 0.8 percent copper oxide and 0.1 percent cobalt acetate. The mixture was fed (free choice) to the steers on plots 1, 2, 3, 5, and 6. Iodized salt was fed to the steers on plot 4. Those on plot 5 also received a protein supplement of 1½ pounds of soybean oil meal per steer daily. White clover had volunteered along with bluegrass and made up 18-25 percent of the forage in plots 3, 4, and 6. Plot 5 contained 44 percent redtop, 20 percent weeds, 20 percent reed canarygrass and 15 percent bluegrass.

[1]Analyses were supplied by Dr. E. G. Benne and associates, Department of Agricultural Chemistry.

Steers on the unfertilized plots ate considerably more of the mineral mixture. The range in weight gained for the 128-day pasture season was 65 to 190 pounds. Steers on unfertilized plot 2, which did not receive protein supplement, made the least gain. Steers on unfertilized plot 5, which received protein supplement, appeared to have insufficient forage during the latter part of the grazing season. No consistent beneficial effect due to the presence of white clover, other grasses, or mineral supplement could be noted.

GENERAL OBSERVATIONS

Because of the nature of the experimental work reported, only general observations are warranted. Individual differences among the steers, as well as the fact that only one or two steers were carried on some of the plots, preclude the making of definite conclusions.

1. Poorer gains were made on the first year's seeding than in any subsequent year. This observation is in general agreement with results reported by farmers.

2. Fertilizer is necessary for maximum forage production. Hay yields were increased approximately 60 percent where 500 pounds per acre of 0-10-30 was used annually.

3. None of the steers during the course of this experiment were thrifty in appearance except those on plot 3 during the 1953 grazing season. These steers ate well and appeared full most of the time during the summer. Seldom did any of the other steers appear as if they were eating more than enough to satisfy hunger partially.

4. The hair on most of the steers stood on end and was coarse and dull in appearance. In many cases a profuse watering of the eyes was noted.

5. Changing the steers to bluegrass or alfalfa-brome pasture (after the close of the pasture period recorded herein) resulted in heavy gains and thrifty appearance.

6. Changes in forage composition of the pastures caused by volunteering of white clover, bluegrass and redtop did not bring about any consistent changes in animal gains or appearance.

7. Confining steers to reed canarygrass pasture only did not give satisfactory or consistent gains in these tests. Studies are planned on larger areas with more steers and further variations in management.

ELECTRICAL RESISTANCE METHODS AS FINALLY PERFECTED FOR MAKING CONTINUOUS MEASUREMENT OF SOIL MOISTURE CONTENT UNDER FIELD CONDITIONS[1]

By GEORGE JOHN BOUYOUCOS
DEPARTMENT OF SOIL SCIENCE

IN ECOLOGY, as well as in the whole field of agriculture and in other fields, there has always been a great need for a satisfactory method of measuring the moisture content of soils. Until a few years ago, the only method in general use for this purpose was the conventional gravimetric one which involves taking soil samples and drying and weighing them. This method, as is generally recognized, is not only time- and energy-consuming but is misleading in studying soil moisture movements, changes, and trends. For example, if soil samples were collected at different dates from the same field and if the samples varied in soil texture any difference in moisture noted could easily be due to differences in texture rather than to movement of moisture.

At the Michigan Agricultural Experiment Station, in an effort to find a more suitable method to measure and study soil moisture in the field, the plaster-of-paris and the nylon electrical resistance methods of soil moisture determination have been devised.

PLASTER-OF-PARIS ELECTRICAL RESISTANCE METHOD

The plaster-of-paris method of moisture determination makes it possible to make a continuous measurement of soil moisture in the field electrically. It utilizes two units, a small porous absorbent block (Fig. 1) and a modified Wheatstone bridge or impedance meter (Figs. 10 and 11). Cast in the block are two parallel electrodes with leads. Such a block when buried in the soil becomes, to all intents and purposes, a part of the soil. It absorbs moisture from the soil and gives it up to the soil very readily, so that its moisture content tends to stay in constant equilibrium with the moisture content of the soil. The electrical resistance of the block varies with its moisture content, and that in turn varies with the moisture content of the soil

[1]This paper was prepared at the invitation of the Eighth International Congress of Botany (Ecology Subsection) to be presented at its meeting in Paris in July 1954.

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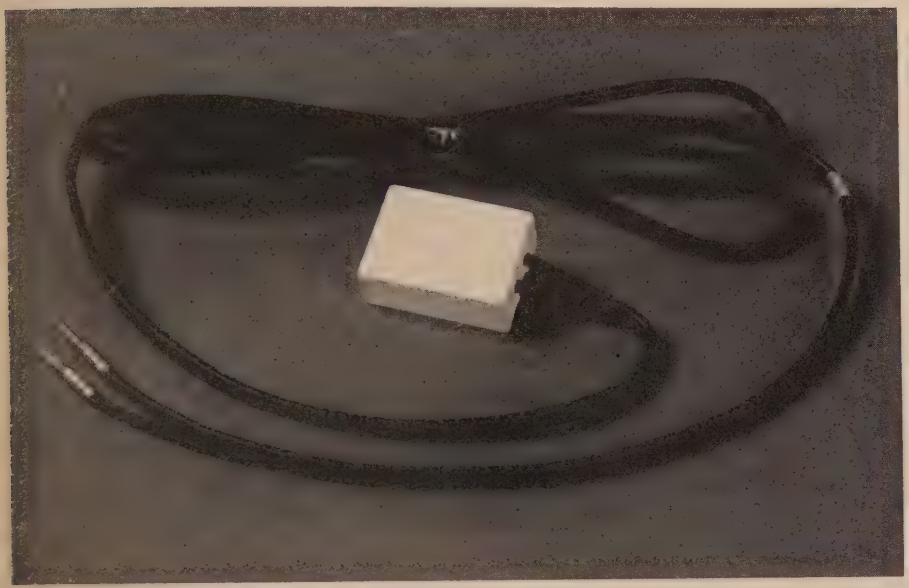

Fig. 1. Plaster-of-paris block as a soil moisture measuring unit.

in which it is buried. Therefore, by calibrating the block the moisture content of the soil may be determined by measuring the electrical resistance of the block. Figure 2 shows the relationship between the electrical resistance of the block and the total moisture content of a typical soil.

The key to the success of this block lies in the fact that the electrodes are covered or imbedded in plaster-of-paris. This gives the electrodes a constant environment so that errors arising from differences in soil compaction, texture, structure, soil type, and electrical lines of force, or "stray currents," are eliminated or minimized. Only units with such internal electrodes have been successful in measuring soil moisture under field conditions. Units with external electrodes have proven unsuccessful. This accounts for the unsuccessful results obtained in past efforts to apply the principle of electrical resistance to soil moisture measurements.

A very important aspect of this electrical resistance method is that it actually measures moisture tension. Its easily effective range is from a field capacity of about 600 ohms resistance to approximately 2,000,000 ohms. In the soil moisture free energy concept this represents the equivalent range of tension from 0.3 atmosphere of pressure to 20 atmospheres of pressure. On the basis of this free energy concept, soils at any given electrical resistance level hold their

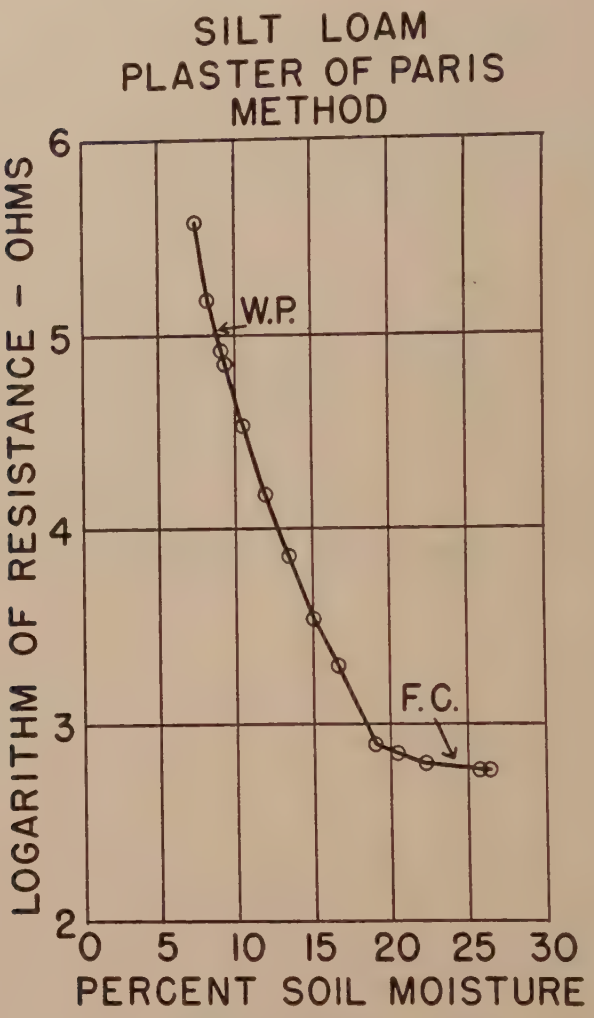

Fig. 2. The relationship between electrical resistance of the absorption block and the total moisture content of a silt loam soil.

water with the same force or tension. For example, at 3,000 ohms resistance a clay and a sandy soil hold their respective water with the same force or tension. This means that a sandy soil containing 8 percent of water at 3,000 ohms is just as wet as a clay soil containing 30 percent of water at the same electrical resistance level. Such being the case, the electrical resistance method makes it possible to detect movements, trends, and changes of moisture in field soils, even though the soils are heterogeneous and not uniform in texture. This represents

a marked advantage over the gravimetric method whose accuracy is greatly affected by textural differences of soils.

There are two soil moisture constants illustrated in Fig. 2. These constants are important in discussing soil moisture in relation to plants. The first is the permanent wilting point (W.P.) This value falls on the moisture curve at about 100,000 ohms resistance. As is well known, the permanent wilting point represents the moisture content in which plants wilt and die. The tension with which the water is held at this point is equivalent to about 16 atmospheres of pressure.

The second soil moisture constant is field capacity (F. C.). This value falls on the moisture curve at about 600 ohms resistance. Field capacity is the maximum amount of water a well drained soil can retain under normal field conditions, and is roughly the moisture a field soil contains about 3 days after it has been soaked by rain or irrigation, the excess water having been drained away and evaporation having been prevented. At field capacity the water is held by the soil with a tension equivalent to 0.3 atmosphere of pressure.

LATEST IMPROVEMENTS IN THE PLASTER-OF-PARIS BLOCKS

The original plaster-of-paris blocks, although devised in 1940, have recently undergone some very important changes and improvements. In the first place, the latest blocks have a different type of electrode. It consists of a 20-mesh stainless steel screen, instead of the straight wire. The plaster becomes enmeshed in the screen to produce a reinforced multiple contact between electrode and the casting. This new type of electrode, eliminates almost completely the capacitance factor, which is large, and which interferes with the electrical resistance readings. It has also effectively eliminated the electrical lines of force or "stray currents" which introduce some error in the results. Finally, the new type of electrode has made it possible to manufacture blocks that are more uniform in performance and more accurate.

Undoubtedly, the most important improvement that has been made on the original plaster-of-paris blocks is to make them more durable. It was discovered through experience that in well-drained soils the original blocks would last usually for more than 5 years. However, in very wet soils, they would often not last more than one season, especially if they were immersed in the water table for any length of time or if infiltration water circulated around them. Under such

conditions the plaster-of-paris blocks would dissolve and disintegrate rapidly. This tendency to short life was unfortunate, especially in installations where it was desired to conduct long-term studies.

In order to make the blocks endure longer under all wet conditions, a search was instituted to find an additive which would act as a binder or protector of the blocks and reduce the rate of their dissolution and disintegration, and thereby prolong their life. The material which was finally found to fulfill the above requirements is an alcohol-soluble nylon resin. By impregnating the plaster-of-paris blocks with the plastic their life is prolonged more than 5 times. The marked durability that the nylon plastic imparts to the blocks is illustrated in Fig. 3. In a durability test the untreated block lost more

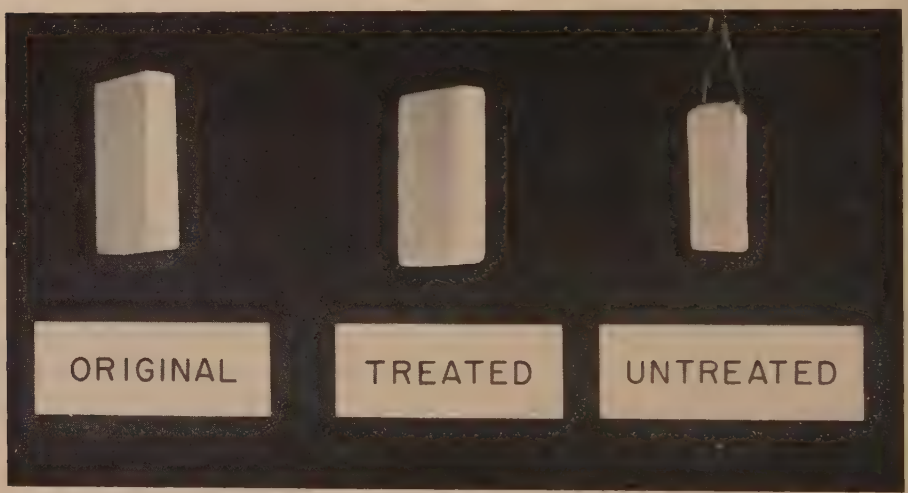

Fig. 3. Comparison of durability of plastic-treated and untreated blocks. Original block shows original dimensions.

than 90 percent of its original weight, whereas, under the same conditions, the treated block lost only 2 percent. The significant fact is that treating the blocks with the nylon resin causes no major change in their original characteristics.

As an example of the actual performance of the plaster-of-paris blocks under field conditions, Fig. 4 is presented. The experiment was conducted under normal agricultural practices. Electrical resistance readings were taken daily by the special soil moisture bridge (Fig. 10), which will be discussed later. The chart shows the rapid response the absorption blocks made to the changes in the soil moisture content.

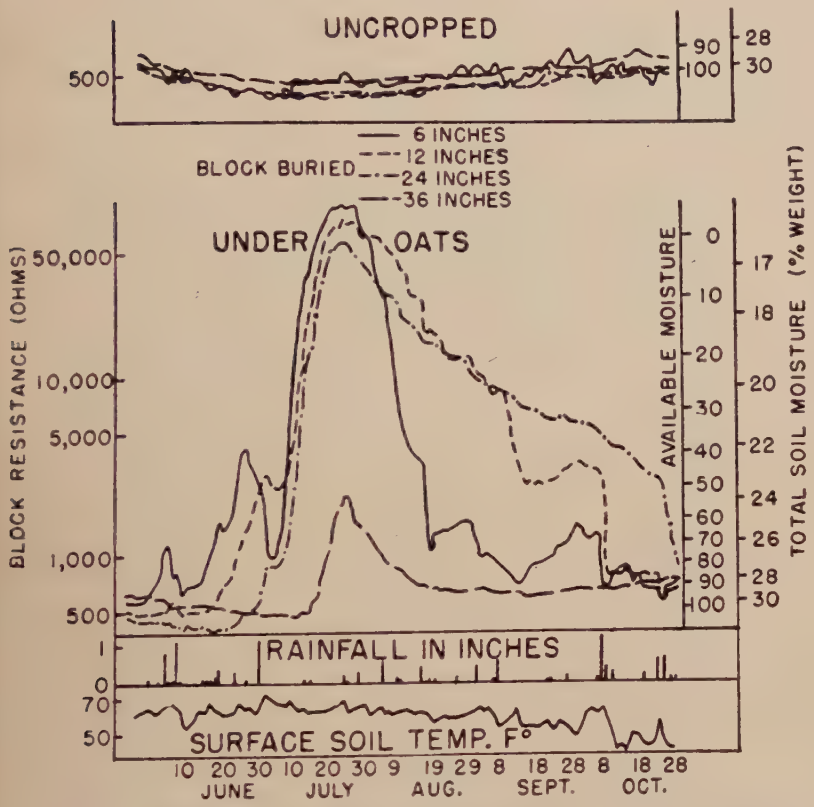

Fig. 4. Showing daily electrical resistance of a clay loam at different depths, uncropped and under oats, and the relative amount of available water at any given resistance reading, as well as the total moisture content at 6 inches depth.

THE NYLON ELECTRICAL RESISTANCE METHOD

The development of the nylon unit is the result of an extensive and intensive search made to find a unit superior in performance and durability to that of the plaster-of-paris block. In this search a great number of materials were examined and experimentally tested. The list includes fire-processed clay, cement and concrete mixture, cement and plaster-of-paris mixture, hydrocal, hydrostone, rubber foam, asbestos, fiberglass, nylon, etc. Of all the materials examined and studied, the nylon fabric proved the most satisfactory.

Out of nylon fabric, therefore, was constructed a soil moisture measuring unit (Fig. 5). It embodys the principle of the plaster-of-paris block and consists of two pieces of stainless steel screen acting

as electrodes, to which are silver-soldered wire leads. These electrodes are separated and wrapped by three single pieces of nylon fabric. The whole assemblage is then placed in a perforated stainless steel case and subjected to a uniform and controlled high pressure.

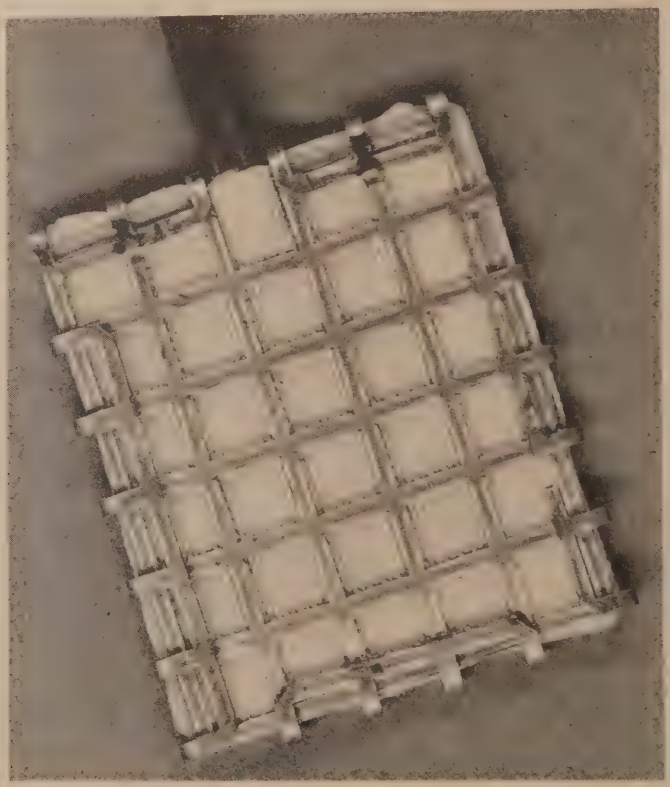

Fig. 5. The original nylon unit as a soil-moisture-measuring unit, based on the same principle as the plaster-of-paris block.

While the center of the unit is being held under constant high pressure the edges of the unit are mechanically united to hold the enclosed assemblage permanently and in intimate contact.

Like the plaster-of-paris block, the nylon unit absorbs moisture from the soil and gives it up to the soil very readily. When the nylon unit is buried in the soil, its moisture content tends to be in equilibrium with that of the soil. The electrical resistance of the unit varies with its moisture content and, by calibration, becomes an index of moisture in the soil.

Also, like the plaster-of-paris blocks, the nylon unit provides a con-

tinuous measurement of field moisture variations. The unit may be installed in the soil at the desired depth and left there permanently. Soil moisture is determined by measuring the electrical resistance of the unit. Resistances are then translated into moisture percentage by means of previously determined calibration curves. A sample of such moisture curves is presented in Fig. 6.

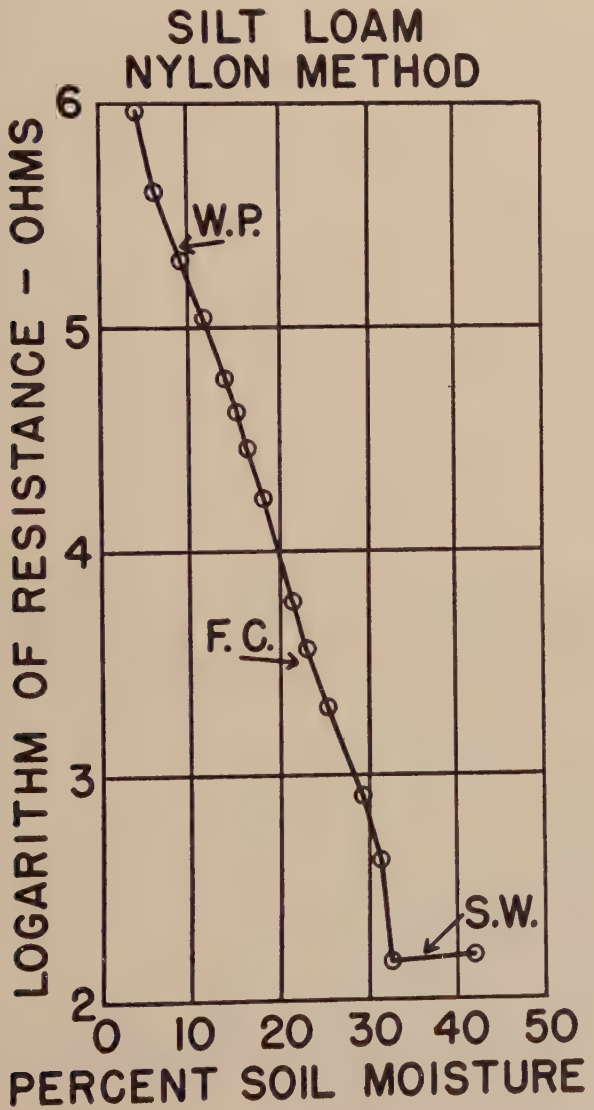

Fig. 6. The relationship between the electrical resistance of the original nylon unit and the total moisture content of a silt loam soil.

An interesting and valuable feature of the nylon units is their outer metal case, which acts as a shield and almost entirely eliminates electrical lines of force or "stray currents".

LATEST IMPROVEMENTS IN THE NYLON UNIT

As in the case of the plaster-of-paris blocks, the nylon units also have recently undergone some important changes and improvements. These improvements are the results of experience and knowledge derived from the use of the original units. The units in their original form (Fig. 5) are extremely sensitive to contact. The outer metal case of the units tends to interfere with a perfect contact between the soil and the units, and this is likely to result in erratic performance by the units. A poor contact will nearly always occur unless great care is taken during the installation to establish a good contact between the soil and the units. In order to give the units a good contact surface at the grid, the nylon units in their original form are now encased in plaster-of-paris, as illustrated in Fig. 7, A and B. The plaster-of-paris casing not only provides the nylon units with a better contact surface but also provides a buffer action which minimizes the effects of salts.

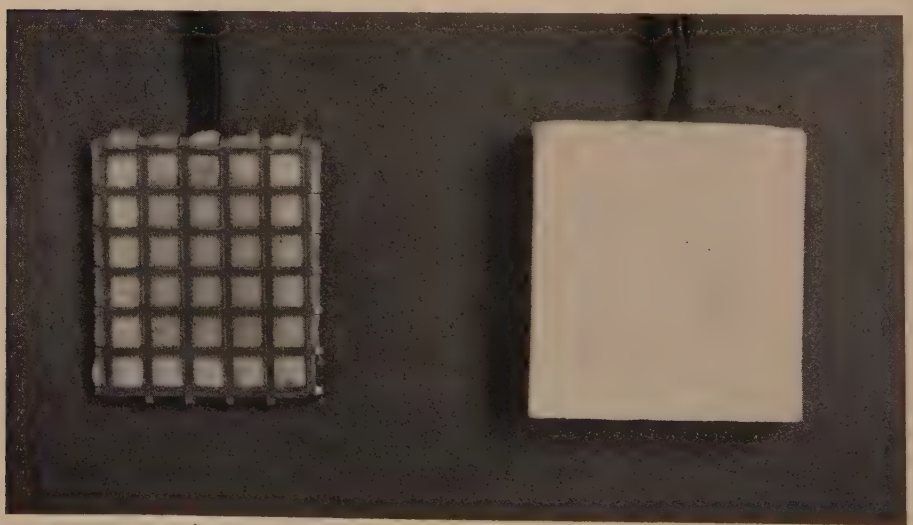

Fig. 7. Improved nylon unit: Original nylon (A); encased in plaster-of-paris (B).

As finally developed, the nylon units possess many outstanding characteristics, the most important of these being:

1) They measure moisture in the soil from near saturation to a point above an air-dry condition.
2) They are particularly suited to measure moisture at the higher levels of water content where other methods are unsatisfactory.
3) They are sensitive in this range, and give reasonably accurate results.
4) They are long lasting.

Perhaps the most outstanding qualities of the nylon device are its marked sensitivity at high moisture contents and the ability to measure moisture near the saturation range. The ability to function with sensitivity at the higher levels of soil water content can be more fully realized by comparing it with the tensiometer method. Table 1 records this comparison.

TABLE 1—Comparison between the nylon method and the tensiometer method in measuring soil moisture in a silt loam

Nylon block	Tensiometer in cm. of water	Total moisture content
Ohms	*Cm.*	*Percent*
140	5	43 (standing water)
140	5	40
155	12	37
210	43	34
250	55	
400	85	31
700	138	
1,120	175	27
2,650	230	
11,000	315	23.8 (field capacity)
79,000	470	22.5
280,000	760	20.3
530,000		17.8
780,000		15.5
1,800,000		9.1
5,000,000		6.5

As is well known, the chief value of the tensiometer method of soil moisture determination lies in its ability to measure soil moisture near the saturation range. It is evident from Table 1 that the nylon device begins to function satisfactorily at almost as high a moisture content as the tensiometer. As long as there is standing water in the soil both

the tensiometer and the nylon methods give constant readings. As soon as the excess water drains away or is evaporated and air begins to enter the pores of the soil, both the moisture tension and the electrical resistance begin to rise at an accelerated rate. The nylon device, therefore, is as sensitive as the tensiometer in measuring soil moisture near the saturation range.

Another striking example of the sensitivity of the new nylon blocks in measuring soil moisture near the saturation range, is afforded by comparing the performance of the nylon block with that of the standard plaster-of-paris block. This comparison, which is shown in Fig. 8,

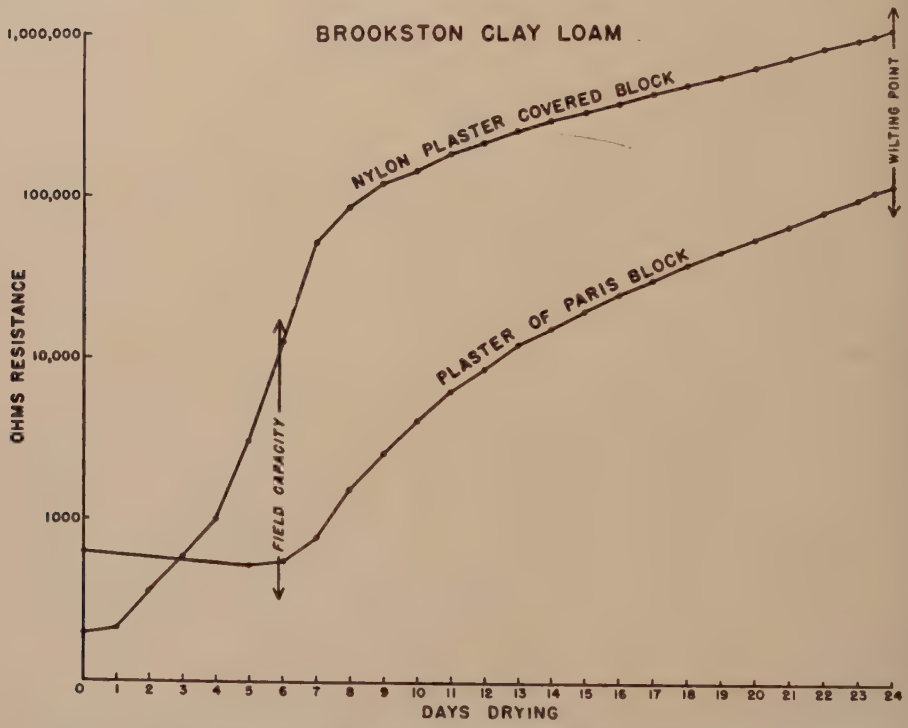
BROOKSTON CLAY LOAM
1,000,000
100,000
10,000
1000
OHMS RESISTANCE
NYLON PLASTER COVERED BLOCK
PLASTER OF PARIS BLOCK
FIELD CAPACITY
WILTING POINT
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
DAYS DRYING

Fig. 8. Comparison between the new nylon block and the standard plaster-of-paris block when placed side by side in a drying cycle of a clay loam.

was obtained by placing the nylon and plaster-of-paris blocks side by side in a two-gallon jar of clay loam soil, and recording their electrical resistance daily under laboratory conditions.

It is readily seen from Fig. 8 that the electrical resistance of the nylon block began to rise almost immediately, while that of the

plaster-of-paris block did not start to rise until the fifth day when the moisture content was reduced to the level of field capacity.

As a sample of the performance of the nylon method under actual field conditions, Fig. 9 is presented.

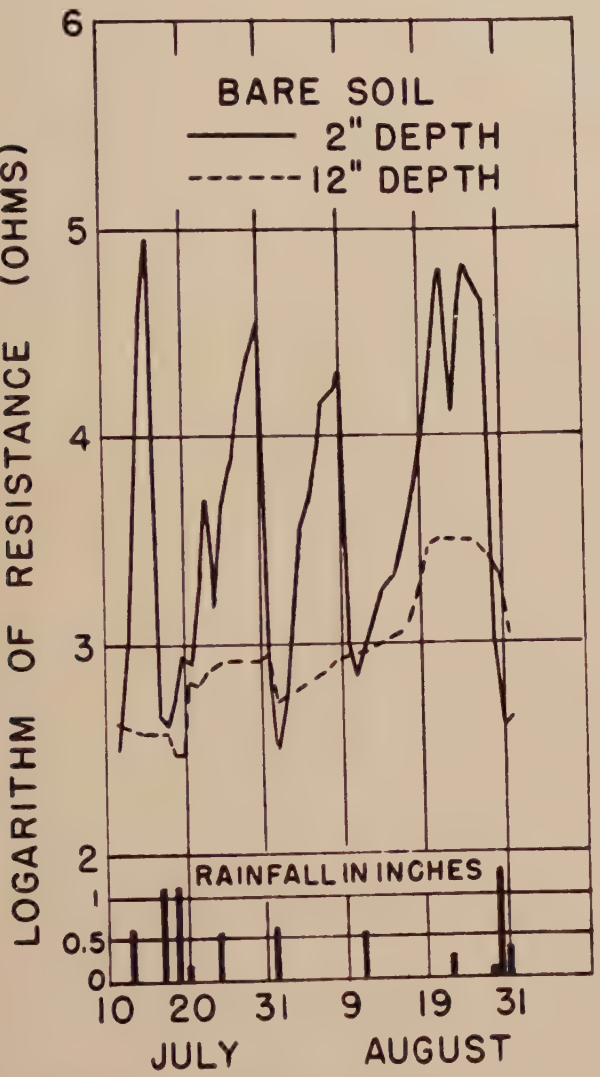

Fig. 9. Sample of performance of the nylon unit under field conditions.

COMPARATIVE MERITS OF THE PLASTER-OF-PARIS AND NYLON METHODS

The plaster-of-paris method had its inception in 1940. Since that time the method has become widely used in many countries. The method has proven a good and reliable one for measuring the available moisture content of soils, or that range of moisture used by the plants. In fact, soil scientists in the United States Department of Agriculture (Kelley *et al.*, 1946), after extensive investigation, state that the plaster-of-paris method "is the most practical instrument available at the present time for measuring moisture changes at tensions above one atmosphere in soils not containing large amounts of salts."

The nylon method, on the other hand, is comparatively new and experience with and knowledge of it, are limited. However, in its latest form wherein the original nylon unit is encased in plaster-of-paris, the method combines the good qualities of the plaster-of-paris block and the nylon unit. It is entirely possible, therefore, that the nylon method may replace the plaster-of-paris method. This action, however, will have to await the final verdict of those who use the two methods. There is no question, however, that the nylon method is the best practical method now available for measuring soil moisture at near the saturation range, and for determining the depth of the water table, rate of drainage, extent of drainage of the soil horizons, etc. If extensive studies and experience do not justify the nylon method replacing the plaster-of-paris method, then the two methods will supplement each other, one covering the higher levels of water content, and the other the lower levels.

EFFECT OF SALTS IN THE SOIL ON THE ELECTRICAL RESISTANCE METHODS

Appreciable amounts of soluble salts in the soil would be expected to affect the accuracy of both the plaster-of-paris and nylon methods since both function electrically. However, there are several factors which tend to modify or minimize the adverse effects of salts:

1) Plaster of paris ($CaSO_4$) is soluble in water to the extent of 2200-2500 parts per million. This solubility factor provides a buffer action which tends to modify or minimize the effect of salts on the electrical resistance readings. Since both units now contain or are made with

plaster-of-paris, they have the benefit of the buffer action of the $CaSO_4$.

2) Experiments have revealed that the effect of salts on the accuracy of the electrical resistance methods are most noticeable near the saturation point. Below field capacity the effects become unimportant. This is because, as the soil dries out, the electrical resistance is dominated by the moisture tension and air space, and not by salts.

3) Leaching, capillary rise of salts, addition of fertilizers, removal of nutrients by plants, continual renewal of soluble salts, etc., tend to compensate each other and thereby minimize the effect of salts on the electrical resistance readings in the humid regions.

4) If necessary, each soil can be calibrated and such calibration takes into account the physical-chemical characteristics and salt content of the soil.

ELECTRICAL MEASURING INSTRUMENTS[2]

Two electrical measuring instruments are used in connection with the plaster of paris and nylon units: 1) a soil moisture bridge (Fig. 10) and 2) a moisture meter (Fig. 11). Owing to lack of space, only a brief mention will be made of these instruments. The bridge is a modification of the Wheatstone bridge. It was built purposely for the plaster-of-paris and nylon soil moisture measuring units. In its present form, it represents the product of 14 years' development. It has a resistance range from 0 to 5,000,000 ohms. It is powered by self-contained dry batteries which activate a 2,000-cycle oscillator. It utilizes headphones, emits a powerful signal, has a large condenser to counteract capacitance effects, and is sensitive and accurate. Although it is intended for research work, it can also be used for practical purposes. It is applicable to both plaster-of-paris and nylon units.

It should be emphasized that a Wheatstone type of bridge is the most accurate instrument for measuring electrical resistance. An ohmmeter, although somewhat more convenient, cannot approach the accuracy of the bridge especially where capacitance is involved. The present soil moisture bridge is now being equipped with some new electronic parts, such as the transistor, new type of oscillator, etc.

The moisture meter is an alternating-current impedance meter based on the circuit of the special soil moisture bridge. It is portable

[2]The plaster-of-paris block, nylon block, moisture bridge, and moisture meter are sold by The Wood and Metal Products Co., Bloomfield Hills, Mich.

Fig. 10. Special soil moisture bridge which has a range from 0 to 5,000,000 ohms resistance. It can be used both for scientific research as well as for practical purposes.

and is powered by dry-cell batteries. It is equipped with transistors which eliminate the use of vacuum tubes and enable the batteries to last a long time. It is calibrated to read directly in percentage of available moisture in the soil. It is more of a practical instrument

Fig. 11. A practical moisture meter calibrated to read directly in percentage of available water in soils. It is intended more for practical purposes.

and is intended to serve as a scientific guide in irrigation practices. Specifically, it is intended to enable farmers, fruit growers, sugar beet growers and many others to know when to irrigate, how much to irrigate, and the depth to which the applied water has penetrated the soil. Such a scientific guide is becoming increasingly necessary not only because it makes it possible to produce better crops more economically, but because the water resources are becoming increasingly scarce and expensive.

One disadvantage of the alternating current impedance meter described above, however, is its relative high cost of production. For the farmer a cheaper meter is needed. A meter based on the direct current principle seems to be the answer to a low-cost meter. Heretofore, a direct current meter could not be used with the plaster-of-paris

blocks because it caused polarization and hydrolosis in the blocks and a drift in the readings took place. However, after a prolonged search it has been found that by using stainless steel-screen electrodes, and spacing them very close together, the factor of drifting is greatly minimized. Studies are still in progress for developing a satisfactory direct current soil moisture meter to serve as an inexpensive guide to irrigation practices. However, up to the present time this type of a moisture meter has not proven satisfactory.

SUMMARY

Two electrical resistance methods have been developed for making a continuous measurement of soil moisture under field conditions. One method employs a plaster-of-paris block and the other a nylon unit encased in plaster-of-paris casting. For greater durability of the plaster-of-paris, both units are impregnated with a nylon liquid plastic. Both units are based on the same principle. The effective range of the plaster-of-paris block is from field capacity to somewhat beyond the wilting point of plants. The effective range of the nylon plaster-of-paris encased units is from near saturation to a point above the air-dry condition.

In comparison with the tensiometer method, the nylon unit begins to function satisfactorily at as high a moisture content as does the tensiometer. The nylon unit, therefore, is as sensitive as the tensiometer method in measuring moisture at the higher levels of water content.

The soil moisture bridge and the alternating current impedance meter have been improved and equipped with some of the newest electronic parts, such as the transistor, new type of oscillator, etc.

These electrical resistance methods have proven successful tools for agronomists, civil engineers, highway engineers, hydrologists and others and are now widely used.

LITERATURE CITED

Bouyoucos, G. J., and Mick, A. H. (1940). An electrical resistance method for the continuous measurement of soil moisture under field conditions. Mich. Agr. Expt. Sta. Tech. Bul. 172.

Bouyoucos, G. J. (1949). Nylon electrical resistance unit for continuous measurement of soil moisture in the field. Soil Sci. 67: 319-330.

———————— (1950). A practical soil moisture meter as a scientific guide to irrigation practices. Agron. Jour. 42: 104-107.

———————— (1951). The effect of fertilizers on the plaster-of-paris electrical resistant method for measuring soil moisture in the field. Agron. Jour. 43: 508-511.

———————— (1954). New type of electrode for the plaster-of-paris moisture blocks. Soil Sci. (in press).

Kelley, Omer J.; A. S. Hunter, H. R. Hause and C. H. Hobbs (1946). A comparison of methods of measuring soil moisture under field conditions. Jour. Amer. Soc. of Agron., 38: 9.

RECOMMENDED FERTILIZER AND PRODUCTION PRACTICES REDUCE UNIT COSTS AND INCREASE NET RETURNS[1]

By C. R. HOGLUND and R. L. COOK
DEPARTMENTS OF AGRICULTURAL ECONOMICS AND SOIL SCIENCE

INCREASED use of improved production practices will be especially important in the years ahead if farmers are to operate at a profit. Machinery, fuel, labor and other costs of production are expected to stay at high levels. Continued high costs, accompanied by lower farm prices and acreage allotments on some crops, place increased emphasis on efficiency. One way to meet this price squeeze is to use practices that boost crop yields and also lower per unit costs. This study points out the opportunities of doing this through the increased use of commercial fertilizer and the following of other recommended production practices.

Recent publications from the Michigan Agricultural Experiment Station[2] show that farmers in the state could greatly increase acre yields by improving their production practices and by applying greater quantities of commercial fertilizers. Most of the practices that increase crop yields also result in lower costs per bushel and per ton, and in higher net returns per acre. These savings are reflected in lower costs of feed on livestock-producing farms.

Considerable progress has been made in recent years in the use of improved production practices. However, most Michigan farmers could greatly improve their production efficiency and thereby reduce costs per unit by making greater use of these practices. Improvement in drainage should be given major attention on many farms. Benefits from using other recommended practices may be completely masked if drainage is inadequate.

[1]Contribution from the Departments of Agricultural Economics and Soil Science of Michigan State College and the Production Economics Research Branch of the Agricultural Research Service, U. S. Department of Agriculture. The authors acknowledge the helpful suggestions received from several members of the Departments of Agricultural Engineering and Farm Crops.

[2]A list of available publications may be obtained from the Bulletin Office, Department of Information Services, Michigan State College, East Lansing, Mich.

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Fig. 1. The use of green manure and minimum tillage operations increase yields and reduce unit costs.

The use of more lime on acid soils will increase production of alfalfa and other high producing hay and pasture crops. Many rotations should include more soil-building and cover crops. Soil compaction is reduced by adopting minimum tillage practices which leave the soil loose enough to allow rapid intake of water. Less run-off means less erosion and higher yields. Use of good quality, adapted seed, timely planting, and efficient weed control are recognized as essential for maximum production.

Although Michigan farmers are using more than twice as much fertilizer as they used 10 years ago they are still applying much less per acre than is recommended for many crops. This increased use of fertilizer has had a marked effect on crop yields. The portion of Michigan's present crop production which is directly the result of commercial fertilizer applied for the current crop has been variously estimated. It is believed that current fertilizer usage contributes 25 percent of the total production, varying with individual crops from

14 to 40 percent. Experimental results indicate that, as an average for all crops, fertilizer application rates should be approximately doubled.

The effects of using present and recommended production practices and fertilizer rates on yields, costs and net returns per acre have been calculated for wheat, oats, corn, alfalfa-brome hay and sugar beets. The yield, cost and net return data presented in this article were based as nearly as possible on the results of field experiments. It was necessary to estimate the expected yields resulting from the interaction between certain recommended production practices, and between the combined practices and recommended fertilizer applications. The data presented in this report are averages for the state. Since fertilizer recommendations vary considerably for different areas of the state, it will be necessary to use judgment in applying the results to a particular soil and area situation.

The cost and returns of producing an acre of each crop were calculated for the different combinations of practices and fertilizer use. Chief considerations were the relative costs and returns for different rates of fertilizer application and different levels of production practices. The costs included fertilizer, manure, seed, a land charge, and all planting, growing and harvesting costs. Pre-harvest costs for recommended practices included extra costs for better drainage, improved machinery, legume seeds, and other rotation expenses. An allowance was made for the cost of applying the extra fertilizer. Tractor, machinery, fuel and oil, labor and other operating costs were based on average field operations performed, multiplied by physical inputs and costs for each operation. Harvesting and hauling costs were those charged by custom operators during 1953. A land charge ranged from $7 to $10 an acre, depending on the location of production within the state for each crop grown.

CHANGES IN CROP YIELDS

WHEAT

Michigan farmers currently apply, on the average, 250 pounds of fertilizer on each acre of wheat for an average yield of 26 bushels (Fig. 2). This yield could be increased to 31 bushels per acre with no change in the rate of fertilizer application by making greater use

of improved practices. This could be done by growing the crop on adapted properly drained soil, by following a good rotation and crop sequence, by using good seed treated for disease, and by tilling the soil properly.

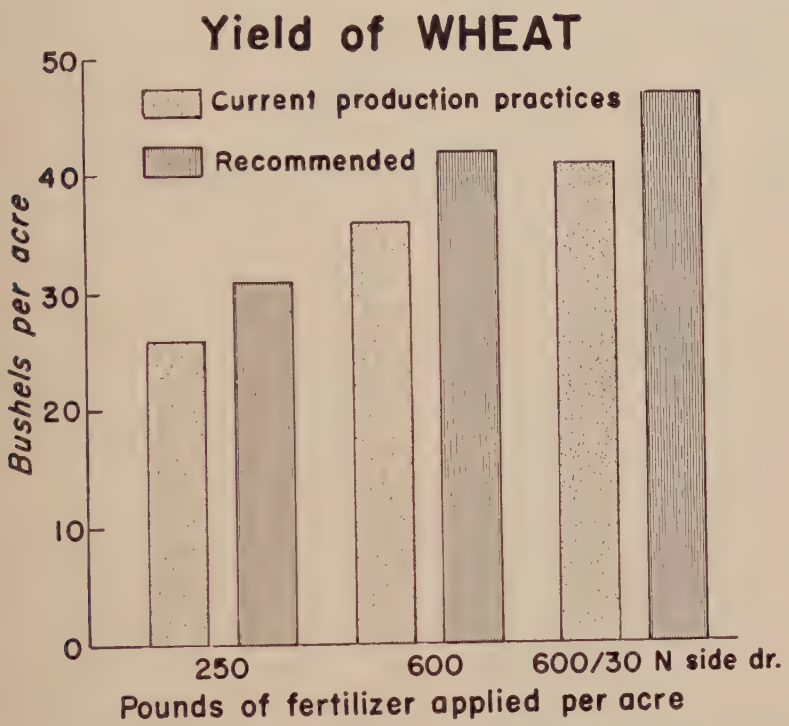

Fig. 2. Estimated yield of wheat when current and recommended levels of fertilizer and production practices are used.

Farmers could push present yields of wheat up to 36 bushels an acre by applying more fertilizer (600 instead of 250 pounds per acre) at planting time and continuing with their present production practices. A still higher yield would result if the improved practices were combined with the recommended application of fertilizer at planting time. If all farmers who produce wheat would follow such a plan, the state's average yield could be increased to 42 bushels an acre.

Still another alternative would be the use of current production practices combined with a 600-pound application of fertilizer at planting time plus a spring topdressing of nitrogen at the rate of 30 pounds

per acre. This combination of practices and fertilizer would result in a state-wide yield of 41 bushels an acre (Fig. 2). Thus, it is seen that the nitrogen would be worth almost as much as the combined improvement in production practices. Highest yields would be obtained if farmers improved their production practices and applied all the fertilizer recommended, including nitrogen as a topdressing. Such a combined effort would bring about an average yield of 47 bushels per acre, an increase of 21 bushels over present yields (Table 1).

TABLE 1—Increased crop yields resulting from adoption of recommended production practices and use of recommended quantities of fertilizer

Crop	Unit	Increase in yield per acre resulting from:		
		Change from current to recommended production practices	Change from current to recommended fertilizer application	Change from current to recommended prod. pract. and fert. appl.
Wheat	bu	5.0	15.0	21.0
Oats	bu	14.0	8.0	24.0
Corn	bu	9.0	13.0	23.0
Alfalfa-brome hay	ton	.7	.6	1.4
Sugar beets	ton	3.5	2.5	6.5

OATS

Oats—a low value crop—are grown extensively because they make a good companion crop for new seedings and because they fit so well into a rotation with corn or sugar beets. Current yields of oats, which average only 38 bushels, are lower than they should be (Fig. 3). Oats yields could be increased by 14 bushels by making full use of improved cropping practices and by 8 bushels by using recommended quantities of fertilizer (Table 1 and Fig. 3). An average yield of 62 bushels would be possible if farmers made full use of improved production practices and applied fertilizer at recommended rates.

Rotations could be arranged in such a way that state average yields of oats might be even higher than those shown in Fig. 3, although by so doing, certain other crops, particularly corn, would suffer. For that reason it is better to conform to the recommendations now being made.

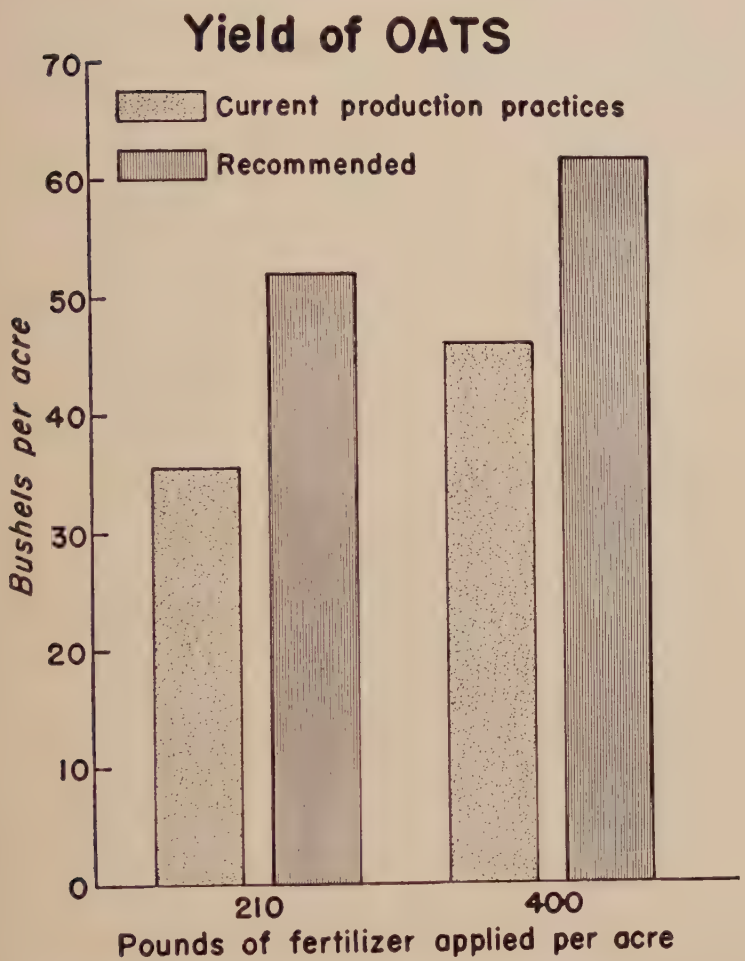

Fig. 3. Estimated yield of oats when current and recommended fertilizer levels and production practices are used.

CORN

Michigan farmers currently produce an average of 38 bushels of corn per acre (Fig. 4). It is estimated that by adopting recommended practices corn yields could be increased to 47 bushels. These would include adequate drainage and lime, use of adapted hybrid seed and improved rotations, correct tillage methods, and efficient weed control.

Corn responds well to nitrogen. It is recommended that the crop receive 200 pounds of a high-grade "starter" fertilizer plus 60 pounds of nitrogen as a sidedressing. When used in connection with current production practices, this fertilizer program would bring about an

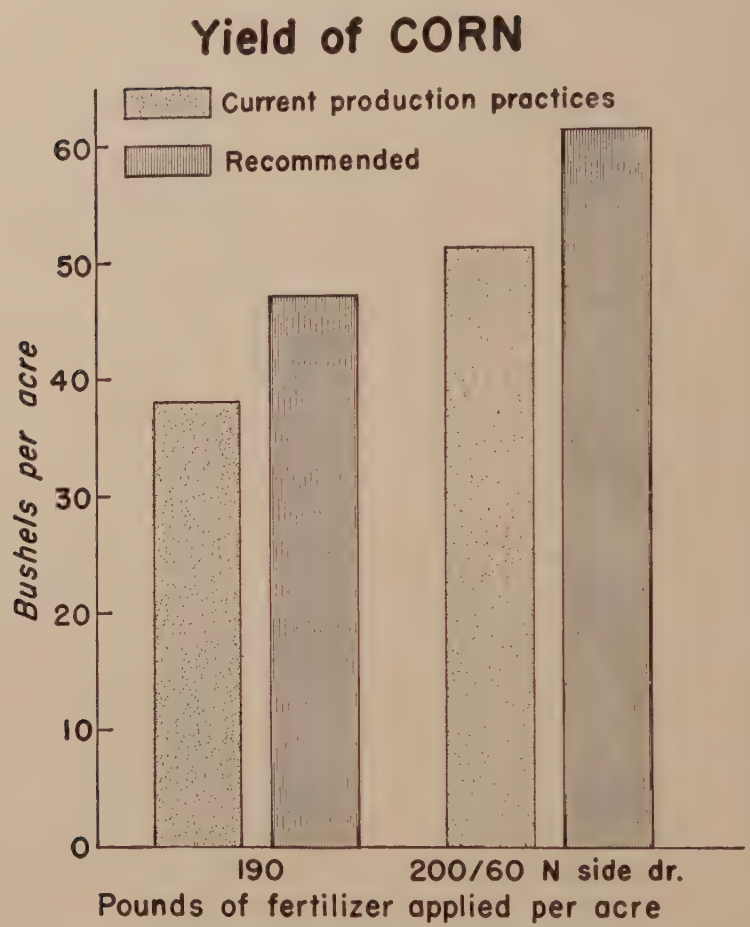

Fig. 4. Estimated yield of corn when current and recommended levels of fertilizer and production practices are used.

average state yield of 51 bushels. A full use of both recommended fertilizer and production practices could result in a yield of 61 bushels of corn.

ALFALFA-BROME HAY

Yields of alfalfa-brome hay have been very low in Michigan in recent years, averaging only 1.8 tons per acre (basis: two cuttings). On a large percentage of farms, the second cutting is used for pasture. Hay yields are low on many farms because the crop is left so long that legume stands become thin, as a result of disease and competition from grasses and weeds. These hay yields could be increased by about

40 percent by improved drainage, by using adequate amounts of lime, by use of adapted seed, by correct seedbed preparation, and by timely planting (Fig. 5). This assumes no change in rate of application of fertilizer.

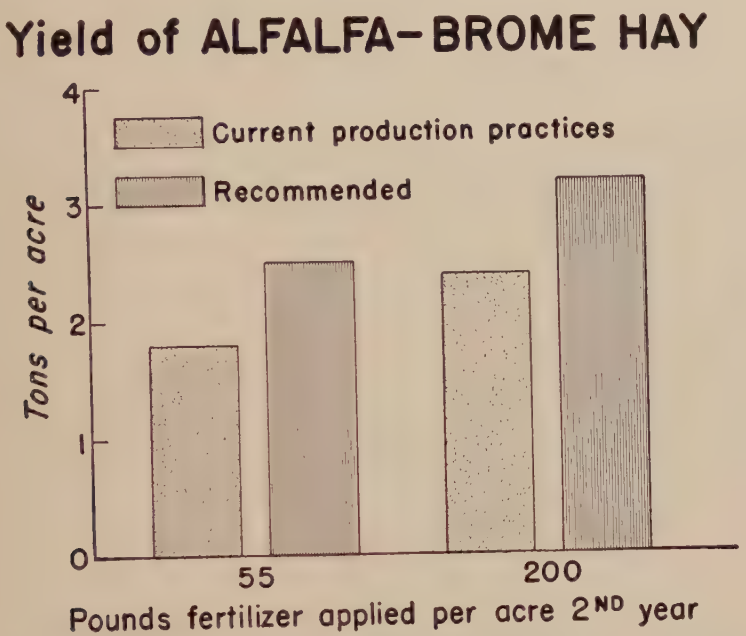

Fig. 5. Estimated yield of alfalfa-brome hay when current and recommended levels of fertilizer and production practices are used.

If farmers made no changes in their production practices but applied at least 200 pounds of fertilizer as top dressing instead of the 55 pounds which they are now averaging, they could expect to increase yields of alfalfa-brome hay to 2.4 tons. By adopting all recommended practices, including the application of 200 pounds of fertilizer on each acre, farmers could push yields to an average of 3.2 tons an acre.

SUGAR BEETS

Sugar beets respond well to increased applications of fertilizer and improved practices. A change to full use of recommended production practices and fertilizer applications would change Michigan farmers' average sugar beet yields from the present 9.0 tons to 15.5 tons per acre (Fig. 6). Recommended production practices include growing on

adapted soil, good drainage, sufficient lime, correct rotation and crop sequence fitted to the soil, correct tillage and weed control, timely planting and improved cultural practices.

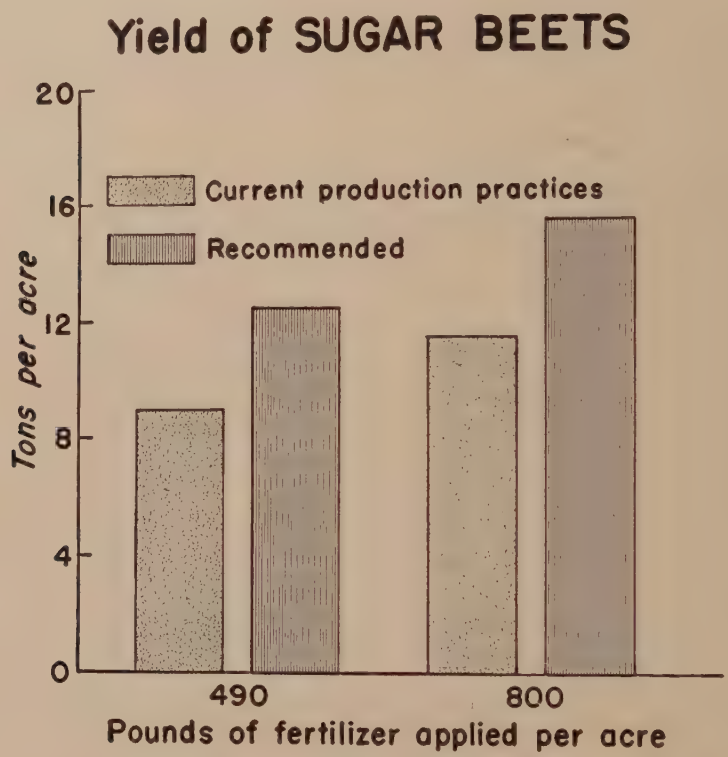

Fig. 6. Estimated yield of sugar beets when current and recommended levels of fertilizer and production practices are used.

On many farms, sugar beet yields could be increased more by improving drainage and using better rotations than by applying higher quantities of fertilizer. Sugar beets, as well as field beans and alfalfa, are sensitive to poor drainage. It is difficult to follow a desirable crop sequence on poorly drained land.

CHANGES IN CROP COSTS

Farmers spend more money per acre in following recommended practices. But by spending an additional $20 per acre in extra costs for recommended practices, they could expect to harvest 21 additional bushels of wheat. Unit cost per bushel would be reduced by $0.26 by

Fig. 7. Improving the drainage may be more profitable than applying more fertilizer on poorly drained farms.

making those expenditures (Table 2). A farmer who adopted improved production practices but made no changes in the rate of fertilizer applied would need to spend an additional $4 per acre and would reduce the cost of producing a bushel of wheat by only $0.11. By spending an additional $16 for fertilizer, he could reduce unit costs by $0.18 without changing his production practices.

The cost of growing a bushel of oats could be reduced by from $0.16 to $0.21 by making changes in production practices or rates of fertilizer applications. As for corn, expenditures for improved production practices would have a greater effect than the application of more fertilizer (Table 2). The combined effects of applying both improved production practices and recommended fertilizer quantities would be to reduce the cost of producing corn by $0.19 per bushel.

Expenditures for drainage, lime and other improved practices are especially important in reducing unit costs for alfalfa-brome hay and sugar beets. A current study in the Saginaw-Thumb Area shows that yields of these and other crops have been increased by as much as 50 to 75 percent by tile drainage. Tile investments on farms in this

TABLE 2—Estimated increase in cost of producing one acre and reduction in cost per unit of production resulting from adoption of recommended production practices and use of recommended quantities of fertilizer

Crop	Unit	Increase in cost per acre resulting from:		
		Change from current to recommended production practices	Change from current to recommended fertilizer application	Change from current to recommended prod. pract. and fert. appl.
		Dollars	*Dollars*	*Dollars*
Wheat		4.22	15.70	20.00
Oats		4.52	4.00	8.52
Corn		4.22	10.55	16.25
Alfalfa-brome hay		5.39	6.37	12.31
Sugar beets		11.50	14.52	27.02
		Reduction in cost per unit:		
Wheat	bu	0.11	0.18	0.26
Oats	bu	0.16	0.17	0.21
Corn	bu	0.14	0.10	0.19
Alfalfa-brome hay	ton	2.55	1.52	3.50
Sugar beets	ton	2.22	1.26	3.26

area have been paid for recently in less than 5 years through increased crop returns.

An increased expenditure of about $12 an acre for fertilizer, lime, better seed and other improved practices could result in a $3.50 reduction in the cost of producing a ton of alfalfa-brome hay. Likewise, a $27 additional expenditure per acre for sugar beets would be expected to reduce production costs per ton by $3.26 (Table 2).

INCREASED NET RETURNS

A net-returns-per-acre figure was arrived at by deducting calculated costs from the value of the crop at 1953 prices. The following values were used: wheat $2.05 a bushel, oats $0.75 a bushel, corn $1.35 a bushel, alfalfa-brome hay $22.00 a ton, and sugar beets $15.50 a ton. Here again, the relative rather than the actual net return figures are the important ones to consider.

Net returns above production costs are closely related to the level of yields. A comparison of Figs. 2 and 8 shows that net returns for wheat increased directly with crop yields. The full use of recom-

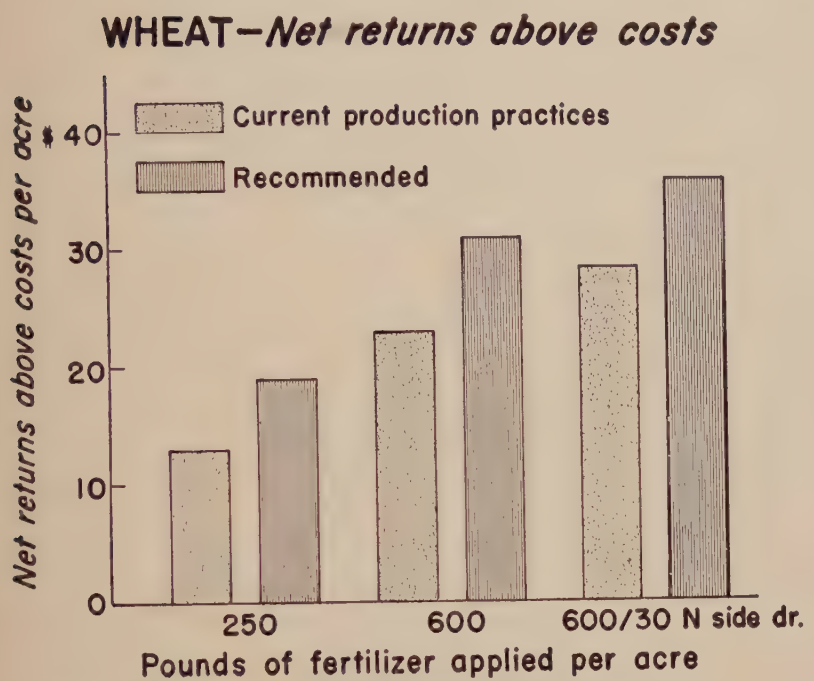

Fig. 8. Estimated net returns above costs in producing one acre of wheat when current and recommended levels of fertilizer and production practices are used. Based on 1953 costs and $2.05 price per bushel for wheat.

mended practices which resulted in a 21-bushel increase in wheat yields increased net returns by about $23 per acre. Full use of fertilizer, including nitrogen as a topdressing, with current production practices would be less profitable by almost $3 per acre than would adoption of recommended practices and the use of 600 pounds of planting-time fertilizer without nitrogen topdressing. This further emphasizes the importance of using recommended production practices.

Oats could become a more profitable crop by following improved practices. A 24-bushel increase in yields, which would be made possible by greater use of fertilizer and adoption of recommended production practices, would increase net returns by about $9.50 per acre (Fig. 9).

In the case of corn, an increased expenditure of $16 per acre for fertilizer and improved practices would result in a $31 increase in

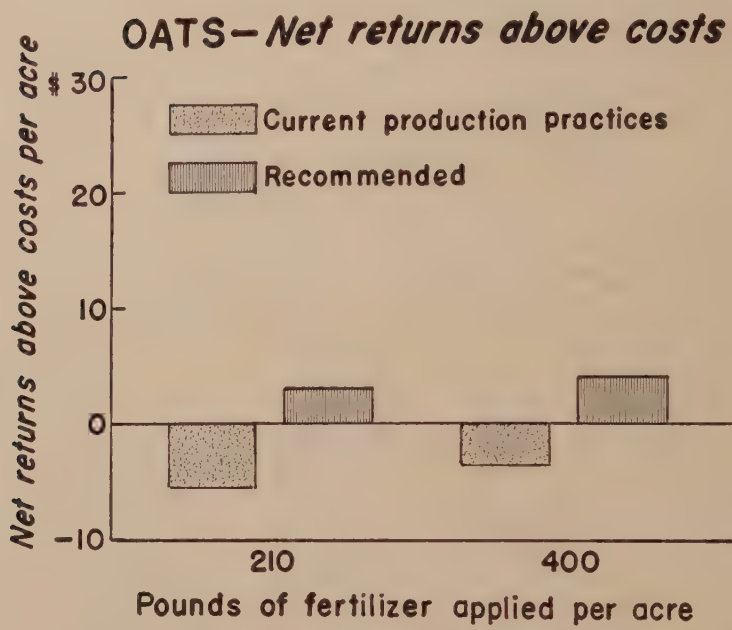

Fig. 9. Estimated net returns above costs in producing one acre of oats when current and recommended levels of fertilizer and production practices are used. Based on 1953 costs and $0.75 price per bushel for oats.

gross returns and a $15 increase in net returns (Fig. 10). An average corn grower who makes improvements only in his production practices or in following fertilizer recommendations would increase net returns by about one-half this amount.

The opportunities of reducing unit costs and increasing the net value per acre are especially good for alfalfa or alfalfa-brome hay (Fig. 11). Using adequate quantities of both lime and fertilizer, and adapted seed, preparing a good seedbed, and following recommended management practices would boost yields and net values of this crop.

Large cash expenditures for fertilizer, labor, machinery and other production items make it very essential that sugar beets growers follow recommendations designed to result in high yields. The increased yield of 6.5 tons which would result from a shift from present to recommended practices would cost $27 more per acre as a result of the greater fertilizer and growing and harvesting costs. However, the increased value of the 6.5 tons of sugar beets would bring about a $74 increase in net returns per acre (Fig. 12).

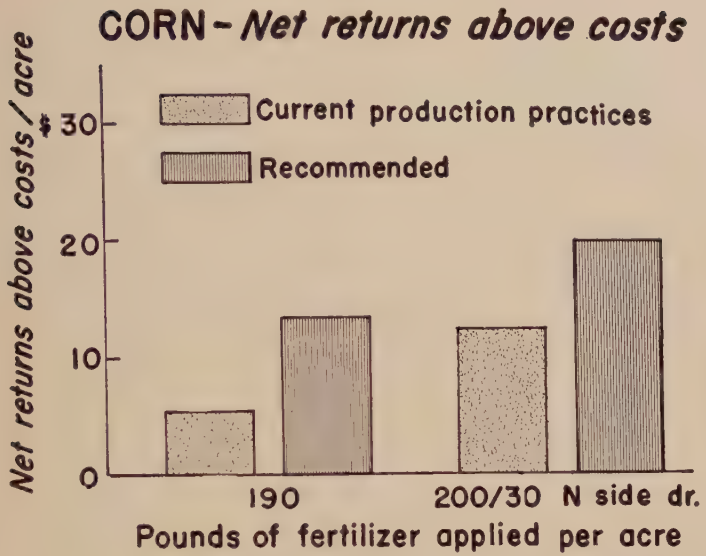

Fig. 10. Estimated net returns above costs in producing one acre of corn when current and recommended levels of fertilizer and production practices are used. Based on 1953 costs and $1.35 price per bushel for corn.

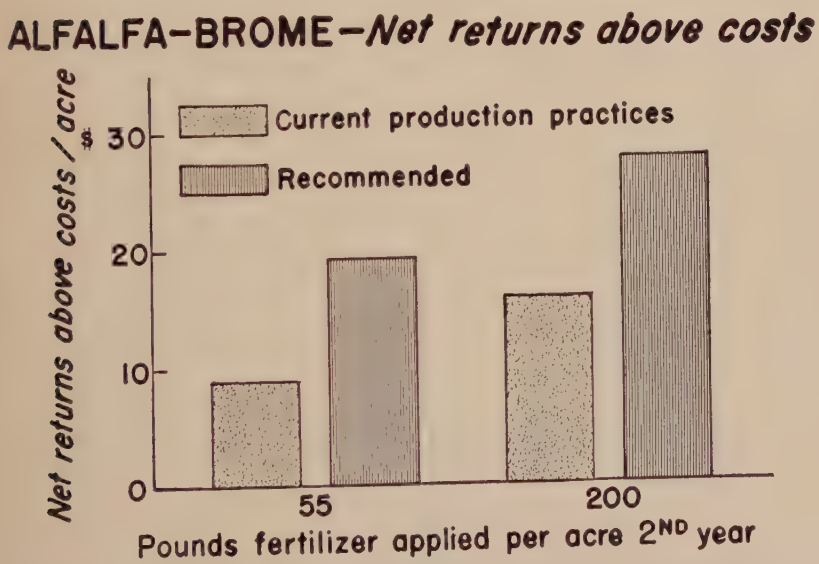

Fig. 11. Estimated net returns above costs in producing one acre of alfalfa-brome hay when current and recommended levels of fertilizer and production practices are used. Based on 1953 costs and $22 price per ton for alfalfa-brome hay.

The importance of better use of production practices that do not involve the use of fertilizer is illustrated in Fig. 12. Under both current and recommended fertilizer usage, marked increases in net

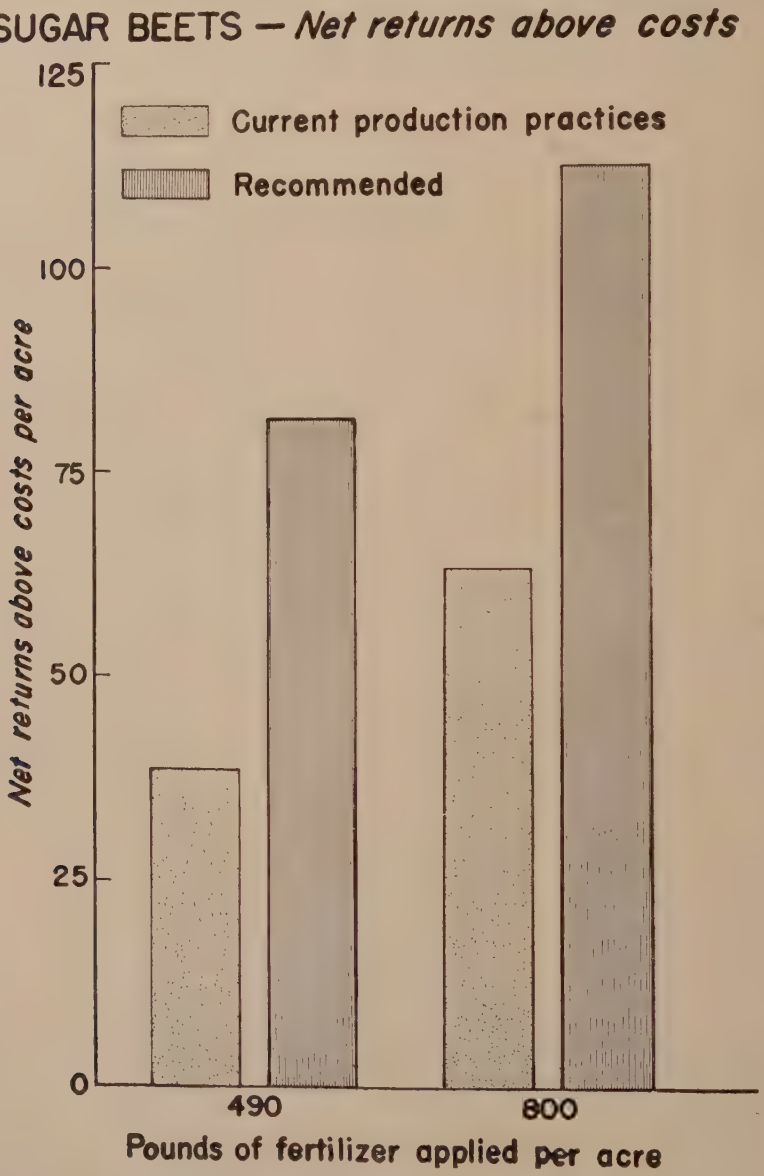

Fig. 12. Estimated net returns above costs in producing one acre of sugar beets when current and recommended levels of fertilizer and production practices are used. Based on 1953 costs and $15.50 price per ton for sugar beets.

returns would result from the adoption of recommended production practices. It would be more profitable to improve practices and continue fertilizer rates at present levels than to apply recommended quantities of fertilizer and retain current production practices.

It should be pointed out that the greater use of improved practices could result in an increased production of crops and lower prices. However, the individual farmer who adopts improved practices and uses more fertilizer will usually be better off financially for having made these changes.

CONSUMER EXPENDITURE PATTERNS FOR APPLES IN 1952[1]

By J. D. SHAFFER and G. G. QUACKENBUSH
DEPARTMENT OF AGRICULTURAL ECONOMICS

THIS is a report of preliminary findings based upon expenditure data for apples from the M. S. C. Consumer Panel[2] for 1952. One purpose of this report is to introduce the Panel, as a source of market information, to those interested in the consumer market for apples. The data are limited to one year's experience and to information dealing only with expenditures.[3] While this limits the application of the study it should nevertheless be useful as a tentative market report. This study addresses itself to such questions as the following: How much do consumers spend for apples and apple products? How do expenditures vary seasonally? How frequently are apples purchased? How much difference is there among the purchases of different families? What factors appear to be associated with these differences? How big would the market be if the average family spent as much for apples as do the largest purchasers? These are some of the questions asked by those involved in the marketing of apples.

In 1952 M. S. C. Consumer Panel families spent more for apples and apple products than for any other fruit except oranges and bananas. They spent an average of about $2.58 for each person during the year for all apples and apple products consumed at home.[4] This amounted to about 12 percent of the total expenditure for all fruits, which averaged $22.50 for each person. The average family spent about 1 percent of its grocery bill for apples and apple products.

Over 99 percent of the families reported purchasing some apples or apple products during the year, the average family buying some apple product about 19 weeks out of the year. Apple purchases are

[1]M. S. C. Consumer Panel Report 1.

[2]A group of approximately 250 families, representative of the population of Lansing, Michigan, who make weekly reports of all food purchases.

[3]It is expected that the study of the purchase patterns for apples will be extended in the near future by including data for 1953 and subjecting them to much more detailed analysis. In this later study quantity and price data will also be considered.

[4]This includes apple products which were identified as being apple and which were purchased for home consumption. It does not include any apple product which might be included in baked goods, such as apple pie or an apple turnover. It does, of course, include all apples purchased to make these products at home.

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of course highly seasonal, as is shown in Fig. 1. While 57 percent of the panel families reported buying apples in some form during the first week of October, only 11 percent reported buying apples during the third week of June. Similarly, expenditures for apples were 14 times as great during the second week of October as during the third week of June.

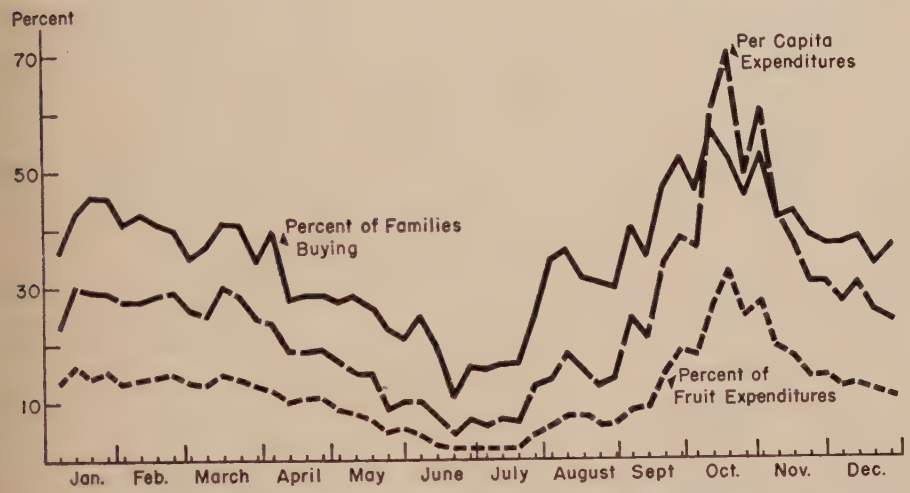

Fig. 1. Seasonal expenditure pattern for apples and apple products. M. S. C. Consumer Panel, 1952.

The proportion of the total expenditures for fruit which was spent for apples also varied seasonally. About 28 percent of the expenditures for all fruit were for apples during the peak month of October, while apples accounted for only about 2 percent in June. It appears that the large expenditures for apples during October may be at the expense of other fruits, since expenditures for total fruit in October were about the same as the average for the year (Fig. 1).

FRESH APPLES

Most apples are purchased in fresh form. Approximately 80 percent of all expenditures for apples reported were for fresh apples.

The reports from panel families indicate that more than 98 percent of the families purchased fresh apples at least once in 1952. The average family purchased fresh apples 12 out of the 52 weeks of 1952;

however, the frequency of purchase varied considerably between families, as is indicated by the fact that:

11 percent purchased fresh apples 26 or more weeks,
30 percent purchased fresh apples 12-25 weeks,
36 percent purchased fresh apples 6-11 weeks, and
23 percent purchased fresh apples 5 or fewer weeks.

The most families to buy fresh apples in any one week was 50 percent, during the week of October 5. The largest expenditure was during the following week, when an average of 12½ cents per person, or 41 cents per family, was spent for fresh apples, with 40 percent of the families reporting purchases. The seasonal expenditure pattern for fresh apples is shown in Fig. 2. Average expenditures during the

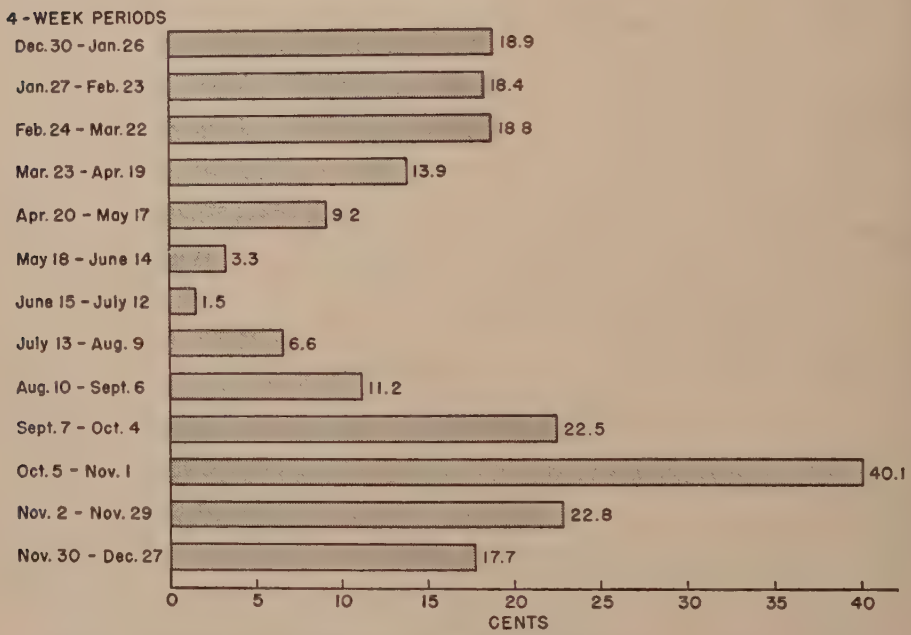

Fig. 2. Seasonal expenditures per capita for fresh apples. M. S. C. Consumer Panel, 1952.

4-week period, October 5-November 1, were over 40 cents for each person, almost twice the expenditures for any other 4-week period. Also, over 40 percent of the total expenditures for fresh apples were made during the 12 weeks between September 10 and Novmber 29.

Twenty percent of the families[5] spent more than $10 each for fresh apples in 1952, while another 20 percent spent less than $2.15 each. The difference between these two groups—the high and the low apple purchasers—is summarized in Table 1. The high-expenditure families spent an average of $15.80 for fresh apples in 1952, 13 times

TABLE 1—Differences in expenditures and characteristics of the largest and smallest purchaser of fresh apples, M. S. C. Consumer Panel, 1952

	Families spending more than $10 for fresh apples (20% of total)	Families spending less than $2.15 for fresh apples (20% of total)
Average annual expenditure for fresh apples per family	$15.80	$1.20
Average annual expenditure for fresh apples per person	$ 4.12	$ .55
Percent group's expenditures for fresh apples were of total expenditures for fresh apples	45	4
Average size of family	3.8	2.2
Average income per family	$4,984	$3,048
Average income per person	$1,300	$1,385
Average age of homemaker (years)	46.3	51.3
Average education of homemaker (years)	11.0	10.3

as much as did the lowest fifth. The average expenditure for fresh apples for each person in the high group of families was about $4.12, as compared with 55 cents for the lowest fifth and about $2.05 for the total sample. The highest fifth spent 45 percent of the total amount paid for fresh apples, while the lowest fifth spent only 4 percent of the total. If the average of all families could be encouraged to spend as much per person for fresh apples as was spent by the high fifth, expenditures for fresh apples would more than double.

On the average, the fifth of the families with the highest fresh apple expenditures were considerably larger and had larger family incomes than the families with the lowest expenditures. There was little difference in the income per capita or in the age and educational attainment of the homemakers between the two groups.

Analysis of the total sample indicated that there was no relationship between the family's income and per person expenditures for fresh

[5]Only those families who returned a complete set of weekly records are included in this case, since the seasonal variation in apple purchases is so great that an individual family's annual expenditures cannot be accurately estimated from a few weeks' experience. This section, dealing with family aggregates, is therefore based upon only 128 families, or about 6,656 reports.

apples.[6] Higher income is not related to higher expenditures per person for apples. Thus, limited income does not appear to be the important factor limiting expenditures for apples.

Expenditures for apples did prove to be significantly related to the number of persons in the family. As the size of family increased, the expenditures per person for apples declined, although expenditures per family increased. The analysis indicated that the annual per capita expenditure for apples tends to decline by about 32 ± 12 cents for each additional member of the family. However, size of family explains only a very small part of the variation in the expenditures for fresh apples.[7]

If one classifies all apples purchased by a family in one week as a purchase, the average expenditure per purchase of fresh apples was about 55 cents. This is based on reports of 2,751 purchases and expenditures of $1,454.56.

The average size of weekly purchase during the first 6 months of 1952 was a little less than 50 cents. The average size of purchase made during July and August was about 42 cents. The largest purchases were made in October, averaging more than 75 cents each. Purchases made during the remainder of the year were somewhat larger than average. In one week, that of October 12, the average purchase was about $1, with about 20 percent of all purchases made exceeding $1. During the entire year, 8½ percent of all fresh apple purchases were $1 or more, while 13 percent were 25 cents or less.

The large consumers of fresh apples were frequent purchasers. The fifth of the families with the largest expenditures for apples purchased apples, on the average, 24.6 weeks out of the year, twice as frequently as did the average of all families. At the same time, the fifth of the families buying the fewest apples purchased apples an average of only 3 weeks out of the year. This indicates that increasing the number of days apples are available to customers for purchase may be an effective way of increasing total apple sales.

The large consumers of fresh apples did not purchase them in especially large quantities per purchase. The average size of purchase for the fifth of the families with the highest expenditures was 64 cents, compared with the sample average of 55 cents. On the other hand, the

[6]Correlation analysis indicated there was no relationship between income per capita or income per family and per capita expenditures for apples. The simple R's were 0.110 and −0.057, respectively, and were not significant.

[7]The regression equation was $X = 3.47 - 0.32(\pm 0.12)Z$, where X is the per capita expenditures for fresh apples and Z the average size of family based upon the number of meals served; i.e., 1092 meals equals one person. The regression coefficient was significant at the 1 percent level of confidence. The correlation was low, 0.24, but significant. R^2 was only 0.058, indicating that size of family explains only about 5 or 6 percent of the variation in per capita expenditures.

average size of purchase per person for the families spending $10 or more for fresh apples was 16.8 cents, compared with 17.6 cents for the families spending less than $2.15. The average size of purchase per person was 16.6 cents for the total sample. In other words, there is essentially no difference in the size of purchases per person between these groups. This indicates that consumers prefer to buy apples in a variety of quantities. Each individual family tends to buy that quantity of apples at one time which is best suited to the needs of the family.

All fresh apples used are of course not purchased. Almost 40 percent of the families reported receiving fresh apples as a gift or using their own home-grown apples during 1952.

PROCESSED APPLES

Approximately 20 percent, or 52 cents, of the total expenditures reported for apples and apple products were for processed apples. Of the total expenditures for processed apples about 15 percent was spent for cider. Twenty-eight percent of the families reported buying cider during the year, and the number of purchases per buyer was 1.7. The average expenditure per purchase of cider was 56 cents. Expenditures for apples processed and sold as baby food accounted for another 15 percent of the expenditures for processed apples.

About 10 percent of the expenditures for processed apples was for apple juice. Twenty-four percent of the families reported at least one purchase of apple juice during the year. The average family buying apple juice purchased it 2.7 times (if the one family which purchased it 28 weeks out of the year is not included in the calculation). The average expenditure per purchase was 25 cents. All other processed apples, including canned applesauce, apple butter, apple jelly, dried and frozen apples, accounted for the remaining 60 percent of the expenditures for processed apples. The data for 1952 were not subjected to a detailed breakdown in respect to these items; however, such analysis will be available from 1953 panel reports.

SUMMARY

Several important, although tentative, conclusions which might be drawn from this study should be noted. The fifth of the families spending the most for fresh apples purchased apples during twice as many weeks as did the average of all families. They did not spend

more per purchase per person than did the average family. If the average family could be encouraged to spend as much per person for fresh apples as was spent by the highest fifth, expenditures for fresh apples would more than double. Since there appears to be little relationship between income and expenditures for apples, the size of the family income does not seem to be the major obstacle to this increased expenditure.[8] It would appear that a fruitful way to expand apple sales would be to have apples available in a large number of stores and in sizes of package or quantities adapted to meet the needs of families of varying size.

[8]This does not mean that more apples would not be purchased if incomes in general were increased. What it does mean is that many families with smaller incomes spend more money for apples than many other families with higher incomes per person.

JOURNAL ARTICLE ABSTRACTS

Easily Constructed Time Saving Apparatus for Filling Dilution Bottles

PIVNICK, H.

Jour. Milk and Food Tech. 15: 16. 1952. (Journal Article 1251 from the Michigan Agricultural Experiment Station)

The hand filling of dilution bottles to be used in the enumeration of bacteria by the plate count method is a tedious and expensive task. A simple, easily constructed, inexpensive apparatus for filling 350 to 400 dilution bottles per hour is described and illustrated with a drawing.

Hormonal Induction of Lactation in Sterile Cows

REINEKE, E. P.; J. MEITES; C. F. CAIRY AND C. F. HUFFMAN

Proc. Book A. V. M. A. 325-328. 1952. (Journal Article 1364 from the Michigan Agricultural Experiment Station)

Experiments are reported on the subcutaneous implantation of pellets of progesterone and stilestrol in varying amounts and combinations to induce mammary gland growth and lactation. Satisfactory lactation was obtained with initial implants ranging from 4 gm. of progesterone plus 2 gm. of stilbestrol in some cases to 3 gm. of progesterone plus 0.1 gm. of stilbestrol in others. In most instances the initial implant was followed in 88 to 124 days with the implantation of 1.2 to 1.5 gm. of stilbestrol. Approximately 30 days later all pellet residues were removed, and milking was begun. Large variations were noted in the amount of hormone absorbed from the implantation site in different animals. In cases of poor hormone absorption lactation was also unsatisfactory. In five cases, including three heifers and two cows, which apparently absorbed optimal amounts of hormone the average butterfat production in a 10-month lactation period was 350 pounds.

Isotopes in Hormonal and Nutritional Studies in Animals

WOLTERINK, L. F.

Paper 12, TID 5098, U. S. Atomic Energy Comm., A Conference on the Use of Isotopes in Plant and Animal Research. (Journal Article 1382 from the Michigan Agricultural Experiment Station)

This paper outlines the basic computational methods employed in research with radioactive tracers and summarizes results obtained at Michigan State College during the last 4 years. These may be briefly indicated as follows:

Hormone Studies

Thyroid output of I^{131} has been followed in ewes, newborn and stillborn pigs, dogs, turkeys and chicks, in addition to the usual rats and mice. I^{131} output from the thyroid is reduced in vitamin B_{12} deficiency. It is lower in slow growing pigs than in rapidly growing ones, and also lower in starved than in normally fed rats. In ewes it is reduced by continuous light, a condition which increases the average number of lambs per ewe. It is stimulated by low doses of estrogen but

depressed by high dosages. The effect of exogenous thyroxine is not yet clear, present data giving anomalous results. There is a very definite "antagonism" between the ovary and the thyroid, however. Thus thyroxine administration abolishes the normal effect of the ovary in increasing Ca^{45} uptake by the femur. Thyroid I^{131} turnovers are not synonymous with thyroid secretion of thyroxine, however. Part of the I^{131} turnover appears to involve di-iodo-tyrosine.

Nutritional Studies

Ca^{45}. Calcium uptake and retention in the femur is markedly reduced by rickets. Femur turnover is "accelerated" by thiouracil (a thyroid depressant) and also by thyroxine, the lack of skeletal retention being reflected by increased uptake in the liver. In the growing rat, the effect of estrogen on femur Ca^{45} turnover is less important than the effect of thyroxine, a result which might not have been obtained in the mouse.

Co^{60}. Cobalt absorption from the digestive tract of chicks is extremely rapid. It is not greatly affected by nutritional deficiencies but appears to be very sensitive to water balance, a lack of water reducing uptake and *vice versa.* Cobalt is absorbed rapidly by intestinal and cecal contents, thus making a large fraction at least temporarily unavailable. The disposition of absorbed cobalt is markedly dependent upon the nutritional and growth status of the bird. Studies on the renal and hepatic elimination of cobalt suggest the presence of complexed forms of cobalt although preliminary studies have not isolated such materials.

A Plan for Sampling a Changing Population Over Time

SHAFFER, J. D.

Jour. of Farm Econ. 36: 153-163. 1954. (Journal Article 1415 from the Michigan Agricultural Experiment Station)

The necessity of obtaining a series of related data with some continuity through time is common to a number of fields of empirical investigation. This paper deals specifically with the sampling problems involved in obtaining detailed consumer purchase records from a human population over time.

Since it was found that cooperativeness is definitely not randomly distributed within the population a sampling technique had to be adopted which recognized this fact. The sampling procedure suggested includes the use of a double sampling technique with substitutes for non-cooperators selected at random from highly stratified sub-groups having similar characteristics. The sample is kept representative of the changing population by continuously sampling the new units in the population and adding them to the sample while dropping those leaving the population. The procedure is essentially that used for the M. S. C. Consumer Panel.

The Dissolution and Migration of Phosphorus from Granular Superphosphate in Some Michigan Soils

LAWTON, K., AND J. A. VOMOCIL

Soil Sci. of Am. Proc. 18: 26-32. 1954. (Journal Article 1423 from the Michigan Agricultural Experiment Station)

Laboratory studies were conducted to determine the rate and extent of dissolution and migration of phosphorus from granular superphosphate in soils.

Chemical and radioactive measurements of phosphorus from experimental and commercial superphosphate indicated a rapid dissolution from the granule. The higher the soil moisture content, the more rapid was the phosphorus dissolution. Variations of the phosphorus level in soils have little effect on the rate at which soluble phosphorus moves out of the granule.

Once in the soil, the fertilizer phosphorus migrated only a short distance, essentially in a spherical zone. By increasing the percent of soil moisture, degree of compaction, or the fertilizer particle size, fertilizer phosphorus movement was substantially increased to a maximum of about one inch from the granule.

The Behavior of Applied Phosphorus and Potassium in Organic Soil as Indicated by Soil Tests and the Relationship Between Soil Tests, Green-Tissue Tests and Crop Yields

BIGGER, T. C.; J. F. DAVIS AND K. LAWTON

Soil Sci. Proc. 17: 279-283. 1953. (Journal Article 1425 from the Michigan Agricultural Experiment Station)

Phosphorus and potassium were extracted from organic soils by rapid test methods, using 0.1 N HCl-0.03 N NH_4F, 0.135 N HCl, and 0.018 N CH_3OOH for phosphorus and 23 percent $NaNO_3$, 0.135 N HCl, and 0.018 N CH_3COOH for potassium.

A highly significant correlation exists between the amount of phosphorus and potash applied and the amount of phosphorus and potassium extracted from the soil. Applied phosphorus remained in the surface soil, while potassium was found to leach down into the 12- to 18-inch depth.

Sugar beets contained 1800 p. p. m. and peppermint 1000 p. p. m. of potassium when the plants showed foliar symptoms of potassium deficiency.

In correlating rapid soil tests, green-tissue tests, and crop yields, it was impossible to establish optimum levels of phosphorus and potassium for maximum yields of sugar beets and peppermint because of the following factors: the physiological nature of the plants, the seasonal variations in plant composition, the differential response of the crops to the fertilizer ratios, and the limitation of the fertilizer analyses and rates of application in this experiment.

The Effects of Various Nutrient Intensities on Growth and Development of Snapdragons *(Antirrhinum majus L.)*

FLINT, H., AND SAM ASEN

Proc. Amer. Soc. Hort. Sci. 62: 481-486. 1953. (Journal Article 1460 from the Michigan Agricultural Experiment Station)

Two varieties of snapdragons, Margaret (inbred) and M. S. C. No. 13, were grown in sand culture at five different nutrient intensities. Osmotic pressures of the solutions used were 0.19, 0.38, 0.73, 1.46 and 2.78 atmospheres. The 0.19 atmosphere solution produced growth similar to that found with the 0.38 atmosphere solution, except that less lateral branching was observed. Nutrient intensities greater than 0.73 atmosphere caused chlorosis, fading of flower color, fewer flowers, decreased dry matter production, and shorter and weaker stems. The nitrogen, phosphorus and potassium contents of the plant leaves all increased nearly arithmetically with geometric increases in the intensities of these elements in the nutrient solution. The hybrid variety displayed more abundant growth,

a slightly higher nutrient requirement, and more severe injury at the high nutrient intensities.

The Extraction and Colorimetric Estimation of Indole-3-Acetic Acid and Its Esters in Developing Corn Kernels

HINSVARK, O. N.; WM. H. HOUFF; S. H. WITTWER AND H. M. SELL

Plant Physiol. 29: 107-108. 1954. (Journal Article 1465 from the Michigan Agricultural Experiment Station)

A colorimetric method for the separate determinations of indole-3-acetic acid and its esters as they occur in developing corn kernels is presented. While some indole-3-acetic acid was present at all stages except in the mature kernels, it reached a peak in fresh corn during the intermediate milk stage. The tomato fruit-setting factor, ethylindole-3-acetate, was found only in kernels which had matured to—or beyond—the intermediate milk stage. The highest concentration of the ester occurred at the same stage of development which characterized the peak in concentration of indole-3-acetic acid.

More Durable Plaster of Paris Blocks Perfected

BOUYOUCOS, G. J.

Soil Sci. 76: 447-451. 1953. (Journal Article 1480 from the Michigan Agricultural Experiment Station)

The plaster-of-paris electrical resistance method for measuring soil moisture in the field was developed about 13 years ago. Since then, more than 125,000 plaster-of-paris blocks have been used. These blocks have now been made more durable by treating them with a nylon resin. This resin is water-insoluble but water-absorptive. It greatly prolongs the life of the blocks, and at the same time it causes no major change in the original characteristics of the blocks.

An Improved Type of Soil Hydrometer

BOUYOUCOS, G. J.

Soil Sci. 76: 377-378. 1953. (Journal Article 1481 from the Michigan Agricultural Experiment Station)

The soil hydrometer for making mechanical analyses of soils has been in use for more than 25 years. Because the method is widely used in most countries, it has seemed advisable to make some improvements in the hydrometer itself and thereby enhance its accuracy and operating efficiency. The new hydrometer is more pronouncedly streamlined. Its dimension remains constant. This is accomplished by molding the hydrometer bulb instead of by blowing it.

Optimum Plot Size for Oat Yield Tests

FREY, K. J., AND W. D. BATEN

Agron. Jour. 45: 502-504. 1953. (Journal Article 1486 from the Michigan Agricultural Experiment Station)

An area planted to a single variety of oats was harvested in 1- by 4-foot plots. Yield data from these one-row units were arranged in plots of various sizes from

one to eight units. The coefficient of variability did not decrease materially for plots larger than four units.

It was found that the regression formula is $S^2_{\bar{x}} = S^2/b^n$ where $S^2_{\bar{x}}$, S^2, b and n represent, respectively, the variance of the mean, the variance of a unit plot, the slope of the regression on double logarithmic paper and the numbers of unit plots represented the data.

When cost functions were considered, the optimum plot size was also four units.

The number of replications necessary to obtain a precision of 3 percent of the experimental mean was found to be five when using the coefficient of variability and nine when using cost functions.

It is pointed out that with current planting and harvesting equipment, the best plot shape was one with four rows, 8 feet long with the two center rows harvested for yield.

Calcium and Phosphorus Metabolism of Women with Active Tuberculosis

BREWER, W. D.; D. C. CEDERQUIST; B. COLE; H. TOBEY; M. A. OHLSON AND C. J. STRINGER

Jour. Amer. Dietet. Assoc. 30: 21-24. 1954. (Journal Article 1491 from the Michigan Agricultural Experiment Station)

The calcium and phosphorus metabolism of six women with moderately advanced, active tuberculosis was studied. Patients were given the customary hospital diet, and adjustments in calcium and phosphorus intakes were made by variations in milk intake. The average calcium retentions were −0.15, −0.16, 0.18, 0.19 and 0.56 at daily mean intakes of 0.73, 1.15, 1.55, 1.79 and 2.30 gm., respectively. The average phosphorus retentions in grams per day were −0.07, −0.14, 0.05, 0.04 and 1.07 at daily mean intakes of 0.73, 1.06, 1.46, 1.88 and 2.62 gm., respectively.

The relationship of intake and retention of phosphorus by the tuberculous women was similar to the relationships reported previously for healthy women. A higher intake of calcium (1.22 gm. daily) was necessary for calcium equilibrium for the tuberculous women than has been found for healthy women.

A Laboratory Study of Various Systematic Sampling Methods Applicable to Forest-Regeneration Surveys

BATEN, W. D., AND J. L. AREND

Mich. Acad. Sci., Arts, and Letters 39: 113-123. 1954. (Journal Article 1492 from the Michigan Agricultural Experiment Station)

The paper reports on the reliability of estimates that were obtained from applying different systematic sampling methods that might possibly have use in forest-reproduction surveys to one artificially created seed pattern of known distribution. Since it is almost impossible to count and map all tree seedlings on a forest tract in order to have a known quantity and distribution as a basis for appraising the reliability of different methods and intensities of sampling, an artificial distribution was created in the laboratory for study. Twenty-five different patterns of systematic sampling which might be used in regeneration surveys were tested. The tests revealed that when only 1 percent of the area is sampled only one-half of the estimates of the total number may be within 50 percent of the actual number. Estimates of the total number or quantity of seedlings should be based on samples totaling more than 4 percent of the area. When the sample

is less than 4 percent, no particular sampling design or sample-plot arrangement can be expected to provide reliable estimates of quantity. Fairly dependable estimates of the percentage of plots stocked with one or more seedlings appear to be possible when as little as 2 percent of the area is sampled. Offsetting a continuous series of 5 or 10 plots diagonally across the sample population may be a sampling method to consider in forest reproduction surveys.

Electrophoretic Studies on the Serum Proteins of Turkeys. II. The Composition of Pullorum Immune Turkey Serum

LYNCH, J. E., AND H. J. STAFSETH

Poultry Sci. 33: 54-61. 1954. (Journal Article 1497 from the Michigan Agricultural Experiment Station)

Studies are presented on electrophoretic analyses of pullorum-immune turkey serum. Pullorum antisera revealed rather characteristic alterations from the normal. The tube agglutination test was carried out in conjunction with electrophoretic analyses for each serum sample. A somewhat definite relationship was shown to exist between the degree of immunization and the relative percentage of serum gamma globulin. In all instances where high agglutinin titers existed, there also was observed a high relative percentage of gama globulin. As antibody titers decreased there was a decrease in the gamma globulin fraction.

The Germination of Okra Seed as Influenced by Treatment with Acetone and Alcohol

ANDERSON, W. H.; R. L. CAROLUS AND D. P. WATSON

Proc. Amer. Soc. Hort. Sci. 62: 427-432. 1953. (Journal Article 1500 from the Michigan Agricultural Experiment Station)

Under favorable moisture and temperature conditions okra seed frequently germinates slowly and irregularly. Under controlled temperatures of 72-75° F. the time required for seedling emergence was reduced by 2 or 3 days and the percentage germination increased by 10-20 percent by soaking the seed for 30 minutes in 95 percent acetone. Treatment with 95 percent alcohol was less effective. Under lower germinating temperatures, below 55° F., the germination process is slowed down to such an extent that the seeds are able to imbibe sufficient water to allow for as rapid germination as can be effected by treatment. However, germination at low temperatures reduces the percentage of germination. The treatment dissolved out fatty materials in the seed coat which were interfering with water movement. Soaking okra seed in 95 percent acetone is recommended for the promotion of more rapid, more even, higher percentage emergence than has previously been possible.

Persistence of Trichloroacetate (Sodium salt) in Different Soil Types

RAI, G. S., AND C. L. HAMNER

Weeds, 2: 271-279. 1953. (Journal Article 1507 from the Michigan Agricultural Experiment Station)

Sodium trichloroacetate (TCA) was applied at three rates, 15, 30, and 60 pounds per acre, to pots containing muck, clay loam and Oshtemo sand. Treatments were made 21, 42, 64 and 108 days before wheat seeds were planted. Thus it was possible to determine the effect of soil type on the persistence of the herbicide.

The data recorded, the fresh and dry weight of tops, the dry weight of roots and the periodic rate of growth of plants showed that crop injury was in proportion to the amounts of TCA application.

The greatest suppression of growth resulted when TCA was applied 21 days before the sowing date of the wheat seeds, irrespective of the nature of the soils. The observations indicated that the sandy soil was the first to show the dissipation of the herbicide. Next in order was clay loam soil and, finally, the muck.

Periodic determinations of nutrient status of the soils did not show any relationship to the crop injury resulting from TCA applications.

Further Investigations on the Use of Maleic Hydrazide as a Sprout Inhibitor for Onions

PATERSON, D. R., AND S. H. WITTWER

Proc. Amer. Soc. Hort. Sci. 62: 405-410. 1953. (Journal Article 1514 from the Michigan Agricultural Experiment Station)

Sprays of 1000 and 2500 p. p. m. of maleic hydrazide applied to the foliage of Early Yellow Globe, Downing Yellow Globe, Brigham Yellow Globe and Michigan State College Sweet Spanish onions 2, 11, and 29 days before harvest gave significant reductions of sprout and root growth during storage. Five hundred p. p. m. applied 11 and 29 days before harvest was also effective in reducing the growth of sprouts. With Y-40 hybrid onions, following 18 weeks of common storage in bins of 200 bushel capacity, only 38 percent of the non-treated bulbs were marketable as compared with 61 percent for those treated with maleic hydrazide.

3-Indolecarboxaldehyde Thiosemicarbazone, a New Antitubercular Compound

WELLER, L. E.; H. M. SELL AND R. Y. GOTTSHALL

Jour. Amer. Chem. Soc. 76: 1959. 1954. (Journal Article 1515 from the Michigan Agricultural Experiment Station)

3-Indolecarboxaldehyde thiosemicarbazone was synthesized and tested for antibacterial activity. The following organisms were not inhibited by 100 micrograms of the compound: *Diplococcus pneumoniae, Streptococcus hemolyticus, Bacillus subtilis, Escherichia coli, Pseudomonas aeruginosa, Salmonella typhimurium, Micrococcus pyogenes* var. *aureus, Klebsiella pneumoniae, Proteus vulgaris, Shigella dysenteriae, Corynebacterium diphtheriae, Aerobacter aerogenes, Mycobacterium phlei, M. smegmatis* and *Mycobacterium* 607.

M. tuberculosis var. *hominis*, strains H_{37R_v}, H_{37R_a} and T_s 1760 were inhibited by 6.2, 0.8, and 3.2 micrograms of the chemical, respectively.

Effects of Pteroylglutamic Acid and Vitamin B_{12} Deficiencies in Chicks Infected with *Ascaridia galli*

BRODY, GERALD

Exp. Parasitol. 3: 240-250. 1954. (Journal Article 1520 from the Michigan Agricultural Experiment Station)

A simultaneous deficiency of vitamin B_{12} and pteroylglutamic acid, using a highly purified semi-synthetic diet, resulted in increased worm numbers and worm length in chicks inoculated with 500 embryonated eggs of *Ascaridia galli*.

A deficiency of PGA increased the number of worms, whereas a vitamin B_{12} deficiency increased only the length of the worms. The addition of vitamin B_{12} to PGA deficient chicks infected with *A. galli* reduced worm length significantly. The addition of 100 mgm. percent vitamin C decreased mean worm numbers and worm length in chicks deficient in both vitamin B_{12} and PGA, but had no effect in the presence of vitamin B_{12}. Evidence is presented to support the concept that leucovorin is biologically equivalent to vitamin B_{12} and PGA and, thus, a simultaneous deficiency of vitamin B_{12} and PGA is in reality a deficiency of leucovorin. A complete pyridoxine deficiency resulted in almost a 100-percent mortality at the end of a 4-week period. Chicks fed a low pyridoxine diet harbored more worms—which, also, were longer—than did birds fed a complete, synthetic diet.

Relation of Time of Harvest to Size, Firmness and Chemical Composition of Fruit of the Sour Cherry (Prunus cereaus)

TAYLOR, O. C., AND A. E. MITCHELL

Proc. Amer. Soc. Hort. Sci. 62: 267-271. 1953. (Journal Article 1524 from the Michigan Agricultural Experiment Station)

An investigation was made to determine the progressive physical and chemical changes that take place in Montmorency sour cherry fruits during a harvest period of approximately 3 weeks.

The soluble solids and total solids content of the fruit increased significantly as the harvest season progressed. The correlation between increase in soluble solids and increase in total solids was highly significant ($r = 0.816$). A decrease in the total solids of the fruit was noted for all trees immediately following 1.27 inches of rain on the 13th day of harvest, after which the total solids of the cherries from all trees continued to increase again until the fruits shriveled on the tree.

The cherries became gradually less firm during the first 2 weeks of the harvest period, and then became rapidly more firm during the third week.

The average transverse diameter of the cherries changed very little throughout the harvest period.

Foliar Absorption and Translocation of Radio Phosphorus by *Chrysanthemum Morifolium*

ASEN, SAM; S. H. WITTWER AND O. N. HINSVARK

Proc. Amer. Soc. Hort. Sci. 62: 466-470. 1953. (Journal Article 1525 from the Michigan Agricultural Experiment Station)

Tracer studies have shown that appreciable quantities of radioactive phosphorus are absorbed by leaves of chrysanthemum plants and translocated to the roots. Increasing the number of foliar applications resulted in a significant increase in total phosphorus in the roots as well as an increase in the percentage of the total phosphorus derived from treatment. Apparently over 8 percent of the total phosphorus in the roots was derived from four successive foliar applications of a 0.3 percent solution of o-phosphoric acid within a 15-day period. The absorption of foliar-applied phosphorus also resulted in an increase in dry weight of both the roots and top portions of the plant.

The Hemagglutionation Reaction in Avian Tuberculosis

RICHEY, D. J.; W. N. MACK AND H. J. STAFSETH

Poultry Sci. 33: 345-350. 1954. (Journal Article 1531 from the Michigan Agricultural Experiment Station)

This study was undertaken with the hope of finding a test for tuberculosis in poultry that might have certain advantages over the presently used tuberculin test. The hemagglutination technique was employed, using sera from tuberculous and non-tuberculous chickens and tuberculin-sensitized sheep red blood cells. The sera of 23 tuberculin-positive chickens exhibiting no lesions had agglutination titers from 1:4 through 1:128. There was no significant increase in hemagglutinins in the serum of apparently healthy chickens "stimulated" with tuberculin.

The Effect of Testosterone and Castration on the Growth and Carcass Characteristics of Swine

BRATZLER, L. J.; R. P. SOULE; E. P. REINEKE AND PAULINE PAUL

Jour. of Animal Sci. 13: 171-176. 1954. (Journal Article 1544 from the Michigan Agricultural Experiment Station)

Pigs were implanted with testosterone pellets, castrated at weaning, at 100, at 140 and at 180 pounds, or were not castrated. Slaughter weights were 215-225 pounds. Carcass measurements, accessory sex gland weights, and cutting data were obtained. Boars and 180-pound castrates had more lean, less backfat, longer body length and a higher primal cutout. No effects were found from testosterone implantation. Treatment did not affect rate of gain or feed efficiency. Castration 5 weeks prior to slaughter eliminated the undesirable odor and flavor found in the boar controls.

The Detection of 3-Indoleacetic Acid in Cauliflower Heads. Chromatographic Behavior of Some Indole Compounds

WELLER, L. E.; S. H. WITTWER AND H. M. SELL

Jour. Amer. Chem. Soc. 76: 629-630. 1954. (Journal Article 1547 from the Michigan Agricultural Experiment Station)

Chromatographic separation of the acid fraction obtained from the ether extract of cauliflower heads yielded three distinct zones having varying degrees of biological activity. That the zone having an R_f value of 0.75-0.77 was 3-indoleacetic acid was ascertained by means of R_f value, co-chromatography with authentic 3-indoleacetic acid, mixed chromatogram with authentic 3-indoleacetic acid, γ_{max} 540 mμ with ferric chloride-perchloric acid and biological activity. The zones having R_f values of 0.62-0.64 and 0.86-0.88 were not identified. The R_f values of a number of indole compounds are reported.

Maturity and Curing Temperatures and Their Influence on Germination of Reed Canarygrass Seed

GRIFFETH, W. L., AND C. M. HARRISON

Agron. Jour. 46: 163-167. 1954. (Journal Article 1564 from the Michigan Agricultural Experiment Station)

The stage of maturity, moisture content of the seed and the temperature at which the seed was dried appeared to be the critical factors which affected the

preservation or loss of viability of reed canarygrass seed. Seed which was harvested early had a high moisture content, and germination was reduced markedly when the seed was dried above room temperature. Seed harvested when more mature was not damaged appreciably when dried at 40° C.

For a period of approximately one week, seed losses due to shattering were compensated for by the growth of the immature seeds in the heads so that seed yields were about equal on three or four successive harvest dates. These results indicate that seed harvest with the combine may well be delayed until 5 to 10 percent of the seeds have shattered and 40 to 50 percent of the remaining seeds have turned brown.

The Riboflavin Requirement of the Baby Pig

MILLER, E. R.; R. L. JOHNSTON; J. A. HOEFER AND R. W. LUECKE

Jour. Nutrition 52: 405-413. 1954. (Journal Article 1574 from the Michigan Agricultural Experiment Station)

Nineteen 3-day-old baby pigs were used in an experiment to determine their riboflavin requirements. Following a 4-day depletion-adjustment period, the pigs were individually fed synthetic milk diets containing 0, 1, 2, 3 and 4 mg. of riboflavin per kilogram of solids. The feeding method was essentially *ad libitum*.

Data on individual growth response and dietary intake were recorded. Analysis of these data indicate that the riboflavin requirement of the baby pig for optimum growth and feed efficiency approximates 3 mg. per kilogram of solids consumer. External, gross and microscopic lesions were present only in those animals receiving less than 2 mg. of riboflavin per kilogram of solids. Deficiency symptoms could be alleviated by riboflavin supplementation.

Prevention by Vitamin B_{12} of Protein Catabolic Action of Cortisone

MEITES, JOSEPH, AND Y. S. L. FENG

Proc. Soc. Expt. Biol. and Med. 85: 341-344. 1954. (Journal Article 1588 from the Michigan Agricultural Experiment Station)

1. Fifty young male rats were divided into five uniform groups and were fed a vitamin B-12-deficient diet for 20 days. For the following 30 days, one group received 200 μg of vitamin B-12/kilo of diet, another was continued on the deficient diet, and the other three groups were injected with large doses of cortisone acetate with or without vitamin B-12.

2. Vitamin B-12 alone did not alter daily urinary nitrogen excretion/100 gm. body weight, but it did increase the appetite and body weight gains. Without vitamin B-12, cortisone significantly increased daily growth and food consumption. Vitamin B-12 largely prevented these protein catabolic actions of cortisone under *ad libitum* feeding, but was ineffective when food intake was reduced to that of rats given cortisone without vitamin B-12.

3. It is concluded that a) vitamin B-12 can prevent increased urinary nitrogen losses induced by cortisone, probably by increasing appetite and thereby enhancing the availability of carbohydrate or protein to the organism and b) large doses of cortisone can markedly inhibit the ability of vitamin B-12 to transform food into body weight gains. Other implications of these findings are discussed.

Distillers' Solubles in Milk Replacers

HUFFMAN, C. F.; C. H. NOLLER AND J. A. WILLIAMS

Proc. 9th Distillers' Feed Conf., March 10, 1954: 12-16. (Journal Article 1604 from the Michigan Agricultural Experiment Station)

Thirty Holstein calves were divided into five groups of six calves each and used to study the effect of supplementing a simple calf starter composed of ground corn, soybean flour, vitamins A, D and B_{12}, antibiotic and minerals, with a) dried brewers' yeast, b) corn distillers' dried solubles, c) corn distillers' dried solubles and dried whey, and d) the basal without antibiotic and vitamin B_{12}. The calves were placed on experiment when 3 days old. Whole milk was limited to an amount not exceeding 56 pounds per calf. No improvement was noted when the basal starter was supplemented with dried brewers' yeast or corn distillers' dried solubles. Calves fed the basal starter, supplemented with a combination of corn distillers' dried solubles and dried whey, showed improved weight gains, healthier appearance and more costive feces. A condition characterized by the adherence of ingesta to the rumen wall as plaques was observed in several of the calves which were autopsied.

A Plastic Plug for Use in the Bovine Rumen Fistula

HENTSCHL, A. F.; R. N. BERRY AND C. F. HUFFMAN

M. S. C. Vet. 14: 77-81. 1954. (Journal Article 1605 from the Michigan Agricultural Experiment Station)

The plastic plug for use in the bovine rumen fistula, developed at the Michigan Agricultural Experiment Station is described. Photographs of various parts of the plug and the intact plug are presented, as well as a photograph of a cow showing the installed plug. One method of placing the plug into the fistula is described.

Accelerated Electron Treatment of Milled Products for the Control of Insects and Their Eggs

BAKER, V. H.; O. TABOADA AND D. E. WIANT

Food Engr. 26: 64-66. 1954. (Journal Article 1618 from the Michigan Agricultural Experiment Station)

Irradiating the product with accelerated electrons offers a means of controlling insect infestation in bulk stored dry foods. Tests were made by the Agricultural Engineering, Entomology and Foods and Nutrition Departments, using a 2-million-volt Van de Graaff electron accelerator belonging to The Upjohn Company, Kalamazoo, Michigan. The results showed that a dose of 10,000 rep prevented adult granary weevils and flour beetles from reproducing and, also, sterilized their eggs. This small dose reduced the germination percentage of seed grain. Larger doses resulted in no emergence.

Preliminary baking tests showed that a satisfactory loaf of bread can be made from wheat flour irradiated with doses of a magnitude far beyond that required to control insects. The difference in taste was not necessarily undesirable. Although depth of penetration of products irradiated with 2-million-volt electrons is limited to 0.35 inch of wheat, the product can be passed through the electron beam so rapidly that 38,000 pounds of wheat per hour can be given an insect-controlling dose.

A Study of Serological Cross Reaction Between the Brucellae and Certain Salmonellae. I. The Antigen Common to Brucella and Salmonella Pullorum

SHKLAIR, I. L., AND H. J. STAFSETH

M. S. C. Vet. 14: 130-135. 1954. (Journal Article 1622 from the Michigan Agricultural Experiment Station)

The purpose of this investigation was to see if there were any cross-reactions between Brucella and certain Salmonellae in serological tests run for the purpose of diagnosing Salmonella or Brucella infections. No cross-agglutination reactions were observed between S. *pullorum* 89817 and Brucella. Cross agglutinations were observed between variant strain S. *pullorum* BAI and Brucella. The antigenic structure of S. *pullorum* is IX, XII_1, (XII_2), XII_3. From the foregoing results it appears that the XII antigen (found in the intermediate and variant strains of S. *pullorum*, or a part thereof, was responsible for the observed cross-reactions. The importance of brucellosis in fowl is discussed.

A Case of Chronic Hog Cholera

THORP, F., JR.; M. L. GRAY AND H. W. DUNNE

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In a herd of 175 swine approximately 30 so-called runts had died. They were not acutely ill but were not normal in appearance. Some of the runts and all of the more normal pigs had been vaccinated for hog chlorea by the simultaneous method. Necropsy examination of two runts, one of which had been vaccinated, showed similar lesions of generalized congestion, hemorrhagic lymph nodes, bronchopneumonia, and button ulcers of the cecum and colon. These intestines were ground, suspended in broth and fed to two weanling pigs, one of which had been vaccinated. The susceptible pig died the ninth post-feeding day. Blood taken one day before death was hemolyzed, filtered and 6.0 ml. injected subcutaneously into a susceptible pig which died on the tenth post-injection day. Necropsy of both pigs revealed lesions of acute hog cholera. The vaccinated pig showed no evidence of illness.

Isolation of *Brucella abortus* Type II (Wilson) from Milk of Dairy Cows in One Herd in Michigan

HUDDLESON, I. F., AND E. A. WHITE

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Brucella abortus Type II (Wilson) has been isolated for the first time from milk of infected dairy cows in Michigan. Strains of *Br. abortus* Type II (Wilson) show the following distinguishing characteristics: 1) They are CO_2-dependent, 2) colonies on agar mediums are small. 3) growth does not occur on agar mediums containing differential dyes, 4) they do not grow on agar mediums containing low concentrations of penicillin G, 5) infection of the udders of cows causes visible changes similar to those of mastitis.

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